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115 Vac Single-Phase Arc-Fault Circuit Breaker Flight Test

Robert Pappas

July 2005

Final Report

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16. Abstract

In December 1999, the Federal Aviation Administration (FAA), the Naval Air Systems Command, and the Office of Naval Research initiated a joint research and development program aimed at the development of arc-fault circuit breakers (AFCB) suitable for the protection of aircraft electrical wiring. Two independent contracts for the development of 115 Vac single-phase AFCBs were awarded; one to the Eaton Aerospace Company and one to the Hendry Telephone Company. Each contractor was to develop arc-fault algorithms and deliver developmental circuit breakers to the FAA and the U.S. Navy for flight test. AFCB detection algorithms were required to be sensitive enough to rapidly identify an arc condition and, conversely, not so sensitive that the device trips on normal electrical transients associated with various load equipment current signatures and electrical power systems operations such as bus transfers. The deliverable circuit breakers were also to be a form-fit replacement for existing thermal magnetic breakers' easy retrofit into aging aircraft. The FAA conducted subsequent flight-testing in an FAA-owned Boeing 727-25C aircraft. Eight aircraft circuits were selected for fitting with AFCBs. The circuits provided a cross section of load types powered from various aircraft power busses. An instrumentation system was installed to record the voltage and current waveforms associated with each circuit to assist in the analysis of any AFCB failure and nuisance-tripping events. This report describes the flight test effort for evaluating the performance of the developmental AFCBs. In total, the flight test effort was comprised of 118.9 hours flight time during which 929.7 operational hours of AFCB data were collected. All flight hours were accumulated using normal aircraft operational profiles.

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LIST OF ACRONYMS

AFCB	Arc-fault circuit breaker
AFCI-JB	Arc-fault interrupter-junction box
APU	Auxiliary power unit
FAA	Federal Aviation Administration
MIDO	Manufacturing Inspection District Office
NAVAIR	Naval Air Systems Command
SCR	Silicone control rectifier
STC	Supplemental type certificate
TDR	Time domain reflectometer

EXECUTIVE SUMMARY

In December 1999, the Federal Aviation Administration (FAA), the Naval Air Systems Command, and the Office of Naval Research initiated a joint research and development program aimed at the development of arc-fault circuit breakers (AFCB) suitable for the protection of aircraft electrical wiring.

Two independent contracts for the development of 115 Vac single-phase AFCBs were awarded; one to the Eaton Aerospace Company and one to the Hendry Telephone Company. Each contractor was to develop arc-fault algorithms and deliver developmental circuit breakers to the FAA and the U.S. Navy for flight test. AFCB detection algorithms were required to be sensitive enough to rapidly identify an arc condition and, conversely, not so sensitive that the device trips on normal electrical transients associated with various load equipment current signatures and electrical power systems operations such as bus transfers. The deliverable circuit breakers were also to be a form-fit replacement for existing thermal magnetic breakers' easy retrofit into aging aircraft.

Eaton delivered the developmental circuit breakers to the FAA and U.S. Navy in August 2001 and Hendry delivered in June 2002. The FAA William J. Hughes Technical Center, Atlantic City International Airport, New Jersey, conducted subsequent flight-testing. For the flight test effort, the circuit breakers were installed in an FAA-owned Boeing 727-25C aircraft. Eight aircraft circuits were selected for fitting with AFCBs. The circuits provided a cross section of load types powered from various aircraft power busses. An instrumentation system was installed to record the voltage and current waveforms associated with each circuit to assist in the analysis of any AFCB failure and nuisance-tripping events.

This report describes the flight test effort for evaluating the performance of the developmental AFCBs. In total, the flight test effort was comprised of 118.9 hours flight time during which 929.7 operational hours of AFCB data were collected. All flight hours were accumulated using normal aircraft operational profiles.

1. INTRODUCTION.

1.1 PURPOSE.

This report describes the flight test effort conducted to evaluate the performance of arc-fault circuit breakers (AFCB) in a Federal Aviation Administration (FAA)-owned Boeing 727-25C aircraft. This report provides a factual summary of the Eaton and Hendry flight test results. Flight-testing of the Eaton breakers was completed in September 2001 and flight-testing of the Hendry breakers was completed in October 2002. The effort was performed by the FAA William J. Hughes Technical Center, Atlantic City International Airport, New Jersey.

1.2 BACKGROUND.

In December 1999, the FAA, the Naval Air Systems Command (NAVAIR), and the Office of Naval Research initiated a joint research and development program aimed at the development of AFCBs suitable for the protection of aircraft electrical wiring. The Eaton Aerospace Corporation and the Hendry Telephone Company were awarded the contract to independently develop 115 Vac, 400-Hz AFCBs. The goal was to add arc-fault protection to existing thermal protection in a package not to exceed an MS24571 size circuit breaker.

Each AFCB contract was tailored around the vendor's proposals. The Eaton contract duration was 24 months and was completed in December 2001. Hendry, who teamed with Texas Instruments, performed under a 33-month contract completed in October 2002. Each vendor proposed various designs for detecting an arcing fault. Existing detection methods developed for 60-Hz residential applications and 48 Vdc telephone systems had to be modified to work on aircraft 115 Vac, 400-Hz electrical systems. Program completion was predicated upon delivery of 20 prototype AFCBs for flight-testing aboard FAA and NAVAIR aircraft.

AFCB detection algorithms must be sensitive enough to rapidly identify an arc condition and, conversely, not so sensitive that the device trips on normal electrical transients associated with various load equipment current signatures and electrical power systems operations such as bus transfers. Unintended trips are referred to as nuisance trips.

Development of effective arc-fault detection algorithms is only one of two major developmental challenges. The other challenge is packaging the arc-fault components along with the components for thermal overcurrent protection into a standard aircraft circuit breaker package. The difficulty posed by this requirement is best illustrated by example. Repackaging an average residential AFCB into an MS24571 package or smaller requires at least a 50% reduction in packaging volume. Exacerbating this challenge is the requirement to operate in an aircraft environment at temperature ranges between -20° and $+71^{o}$C, altitudes of 0-45,000 feet, with vibration, electromagnetic interference, and operating on electrical systems with many unusual electrical transients. Both companies exceeded the program goal and developed AFCBs in packages substantially smaller than the MS24571 goal. Figures 1 and 2 show the Eaton and Hendry prototype AFCBs, respectively.

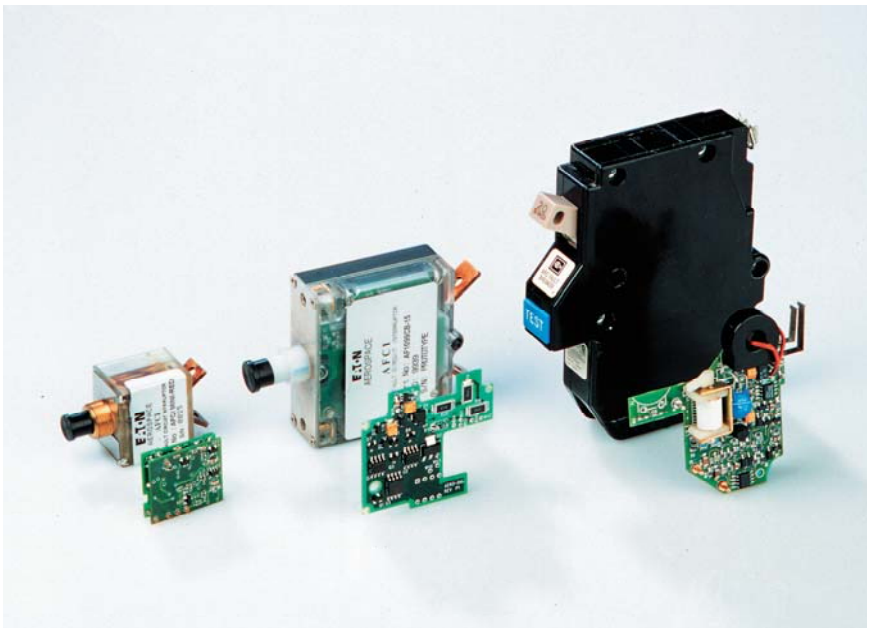


FIGURE 1. EATON AEROSPACE CORPORATION PROTOTYPE AFCBs
(Two left breakers are 400-Hz prototypes. Right breaker is a 60-Hz residential breaker.)



FIGURE 2. HENDRY TELEPHONE PRODUCTS AFCB

1.3 TEST OBJECTIVE.

The objective of the AFCB flight test program was to evaluate the nuisance trip characteristics of each vendor's AFCB prototypes. A nuisance trip is a nonthermal opening of the AFCB when an arc-fault condition is not present. Nuisance trips are most likely when loads are initially turned

on, or during bus transfers and other transient conditions. However, nuisance trips can occur at any time, due to a random transient or other electrical system upset.

To achieve the flight test objective, the goal for the flight test program was simple. Operate the breakers on the aircraft, following standard aircraft operating procedures, for at least 25 hours and up to 50 hours if possible. Additional flight hours increase the likelihood that the AFCB prototypes are exposed to as many potential nuisance trip conditions as possible.

It is important to stress that evaluation of the arc-fault detection implementation methods and trip time performance was not a flight test program objective. The vendors conducted hundreds of dry- and wet-arc tests during the development process to evaluate the arc-fault detection performance of their product. More importantly, conducting arc-fault tests in flight is a hazard to the aircraft and crew. All breakers were subjected to manufacturer conformance testing and were subjected to FAA dry-arc (guillotine) tests prior to installation on the aircraft.

It must also be noted that the flight tests were not part of a product qualification program. The AFCBs tested in this program were engineering prototypes, not production representative units. In addition, there is no standard performance specification for AFCBs currently published. However, development of an AFCB performance specification continues in the SAE AE-8B1 Protective Devices Subcommittee and is expected to be completed in the near future.

2. EQUIPMENT INSTALLATION.

2.1 AIRCRAFT DESCRIPTION.

Testing was performed at the William J. Hughes Technical Center aboard the FAA's only large transport category aircraft. The aircraft is a B-727-25C (tail number N40) aircraft manufactured in 1967. Three main engine generators, an auxiliary power unit (APU), and an emergency battery bus electrically power the aircraft. On the ground, the aircraft is powered by the APU or from a ground power unit. The AFCBs were tested using all sources of power except for the emergency battery. The aircraft is equipped with a 400- to 60-Hz converter that supplies 115 V/60 Hz power to the project instrumentation and data recorder.

The aircraft was flown under an experimental certificate issued by the local FAA Field Service District Office.

2.2 ARC-FAULT CIRCUIT BREAKER FLIGHT TEST INSTALLATION DESCRIPTION.

2.2.1 Circuit Breaker Installation and Connection.

The AFCBs were not installed in the aircraft circuit breaker panel because they were nonqualified prototypes. Therefore, the breakers were installed in a separate arc-fault circuit interrupter-junction box (AFCI-JB) that contained all the AFCBs and instrumentation interfaces. It is important to note that the AFCBs were connected in series with the load side of the existing aircraft thermal circuit breakers. Existing circuit protection aboard the aircraft was not compromised in any way by this installation. Additionally, a trigger test point was brought out from each breaker and used to activate an audible alarm and put the instrumentation recorder in a high sampling rate mode.

The AFCB installation consisted of the following components:

a. Eight Eaton or Hendry prototype AFCBs of the following ratings: one 2.5 amps (A), three 5 A, two 7.5 A, one 10 A, and one 15 A. The AFCBs were mounted inside the AFCI-JB.

b. One AFCI-JB. The AFCI-JB (figure 3) housed the eight AFCB units. It also contained eight current transformers for monitoring the current flowing through each of the eight AFCBs and a voltage divider network for monitoring the voltages on the line and load side of each breaker. The AFCI-JB is mounted in the rear, left side of the cockpit behind the observer jump seat. The AFCI-JB has bypass switches that disable the AFCBs, if desired, by the pilot in command. The banana plug jacks along the bottom of the front side provide convenient electrical access to the line and load side of each AFCB to assist in testing and troubleshooting activities. The AFCI-JB was fabricated using standard best practices and in accordance with Advisory Circular 43.13-1B and was designed to contain any possible AFCB failures.

c. Two AFCI-JB test unit wire harnesses, P18 and P6 (for connection to the P18 and P6 circuit breaker panels, respectively).



FIGURE 3. ARC-FAULT CIRCUIT INTERRUPTER-JUNCTION BOX

2.2.2 Instrumentation Equipment and Interfaces.

The flight test instrumentation was mounted in the cabin of the aircraft. The following equipment was installed to support the data collection effort.

a. One 24-channel Nicolet Odyssey data recorder. (The data recorder was upgraded to 32 channels for the Hendry AFCB flight tests.)

b. One BNC breakout box. The breakout box routed the signals from the shielded, twisted pair wires in the interface harness (see paragraph c) to a standard BNC connector, one for

each input channel on the data recorder. The BNC breakout box and the Odyssey data recorder were mounted in the cabin of the aircraft, as shown in figure 4.

c. One AFCI-JB, BNC breakout box interface harness. This harness contained shielded, twisted pair wires for carrying the signals obtained in the AFCI-JB to the BNC breakout box.

d. Twenty-four 36-inch BNC connector cables. These cables connected the outputs on the BNC breakout box to each input channel on the data recorder.

e. One Trigger Alarm. The trigger alarm was an audio/visual alarm that illuminated a warning light and sounded a siren in the event the data recorder experienced a trigger signal, indicating a potential AFCB trip or other anomaly. Pressing a pushbutton mounted on the alarm resets the alarm.



FIGURE 4. NICOLET DATA RECORDER AND JUNCTION BOX

2.3 ELECTRICAL CONNECTIONS.

The electrical connections for the system are shown schematically in FAA drawing 9854415, as shown in appendix K. The AFCBs mounted within the AFCI-JB will be electrically in series with the load side of the existing circuit breakers. The AFCI-JB wire harnesses, P-18 and P-6, connect the load side of the each aircraft circuit breaker to the line side of the respective AFCB and the load side of the each AFCB to the feed wire for the respective load. The AFCI-JB-BNC breakout box interface harness connected the AFCI-JB to the BNC breakout box.

Connections between the BNC breakout box and the Odyssey data recorder are shown in figure 5.



FIGURE 5. BNC BREAKOUT BOX TO NICOLET DATA RECORDER

2.4 AIRCRAFT TEST CIRCUITS.

The prototype AFCBs were tested on the aircraft circuits indicated below. The circuits were selected through an iterative process. First, all ac loads on the aircraft were identified. All flight critical and essential loads were eliminated. Three-phase motor loads were also eliminated. From the remaining circuits, a cross section of loads was selected to optimize the mix of load types (resistive, inductive, electronic, etc.) These loads are specified below.

- Left inboard landing lights, 7.5 A, 115 Vac, ac bus number 1, circuit breaker panel P18-4.
- Left outboard navigation light, 5 A, 115 Vac, ac bus number 2, circuit breaker panel P18-4.
- Left window lights, 10 A, 115 Vac, transfer bus, circuit breaker panel P18-3.
- Left ceiling lights, 15 A, 115 Vac, transfer bus, circuit breaker panel P18-4.
- DME-2, 2.5 A, 115 Vac, ac radio bus number 2, circuit breaker panel P18-2.
- Auxiliary pitot heat, 5 A, 115 Vac, ac bus number 2, circuit breaker panel P6-1.
- Window heat, first officers window 4 and 5, 5 A, 115 Vac, ac bus number 3, circuit breaker panel P6-1.

- 400- 60-Hz inverter (phase A only), 15 A, 115 Vac, ac bus number 2, project power junction box (located in E&E bay).

2.5 NICOLET ODYSSEY DATA RECORDER.

A Nicolet Odyssey data recorder (figure 6) was used to record all data from the AFCB-JB. The Nicolet is a sophisticated data recorder that samples at a rate of 100 kHz per channel. Data recording rates are programmable for speeds between 1 and 100 kHz. To conserve hard disk space, data was normally recorded at the 1 kHz rate. When the data recorder detected a trigger, indicating that an AFCB was tripping, the recording rate would immediately change to the 100 kHz rate, capturing a high-resolution recording of the voltage and current on each AFCB for 100 ms before and after the trigger condition.

The capture of this data was important for several reasons. First, the current waveform data is crucial in determining if the fault condition was a real arc fault or a nuisance trip condition. If a real arc was suspected, a rigorous troubleshooting effort is required to find the location of the fault on the aircraft prior to release for flight, as spelled out in the Eaton Troubleshooting Procedures in appendix E. If the condition is determined to be a nuisance trip, the data is sent to the AFCB developer for analysis, and possible modification of the arc-fault detection algorithms in the AFCB.



FIGURE 6. NICOLET ODYSSEY DATA RECORDER

2.6 N40 WIRING BASELINE.

As required in the Eaton Ground Test Checkout Procedures shown in appendix C, the eight circuits involved in the AFCB testing were required to have an electrical characteristic baseline

established prior to commencing the flight test. CM Technologies was brought in to use its electrical characterization and diagnostics time domain reflectometer (TDR) to measure and record the baseline.

Baselines were established to assist the troubleshooting process in the event that an AFCB trip occurred. If the recorded data clearly indicated that the event was nuisance related, then troubleshooting of the aircraft circuits would not be necessary. However, if the data recorded was inconclusive, then it might be necessary to troubleshoot the aircraft circuit. Because an arc fault can alter the impedance characteristics of a wire, it was determined that the TDR may help locate the approximate location of the arc.

During a TDR test, an electric pulse is transmitted down the wire under test. Wherever an impedance change is encountered, part of the energy of the pulse is reflected back to the source. The reflections are captured as a trace. The initial trace is stored as a characteristic baseline against which future traces are compared. In the event of a suspected arc fault, the wire would be recharacterized and the new trace compared to the original baseline. When the traces are overlaid, separations indicate potential areas where the wire has been damaged. Appendix J contains the baseline characterization data from the N40 tests.

During both the Eaton and Hendry flight test programs, no arc faults were encountered, and it was not necessary to recharacterize any circuits with the TDR measurement equipment.

3. FLIGHT TEST STATISTICS.

The combined flight evaluation included 118.9 hours of testing. During this time, a total of 929.7 AFCB operational hours and data were accumulated. The Flight Test Certification Plan is shown in appendix A.

3.1 EATON FLIGHT TEST STATISTICS.

Figures 7 and 8 contain the summarized Eaton flight test data. Figure 7 shows the flight hour data, and figure 8 shows the cumulative AFCB operational hours. The Eaton AFCBs accumulated 30.9 flight hours and 228.2 operational hours. Appendix D contains the detailed data on the flights.

The Eaton flight test program commenced on 10 September 2001. On the morning of 11 September, the aircraft was powered-up and ready for taxi and takeoff when the World Trade Center and Pentagon attacks began to unfold. This flight and all other flights for the week were cancelled. The program was able to resume testing on 17 September. During the period of 20-25 September, a number of instrumentation and crew availability problems were experienced that further impacted accumulation of flight time. Flying resumed on 26 September and continued through 03 October. At this point, the aircraft was removed from experimental status to support other scheduled FAA research and development (R&D) flight test programs and the Eaton flight test program was completed.

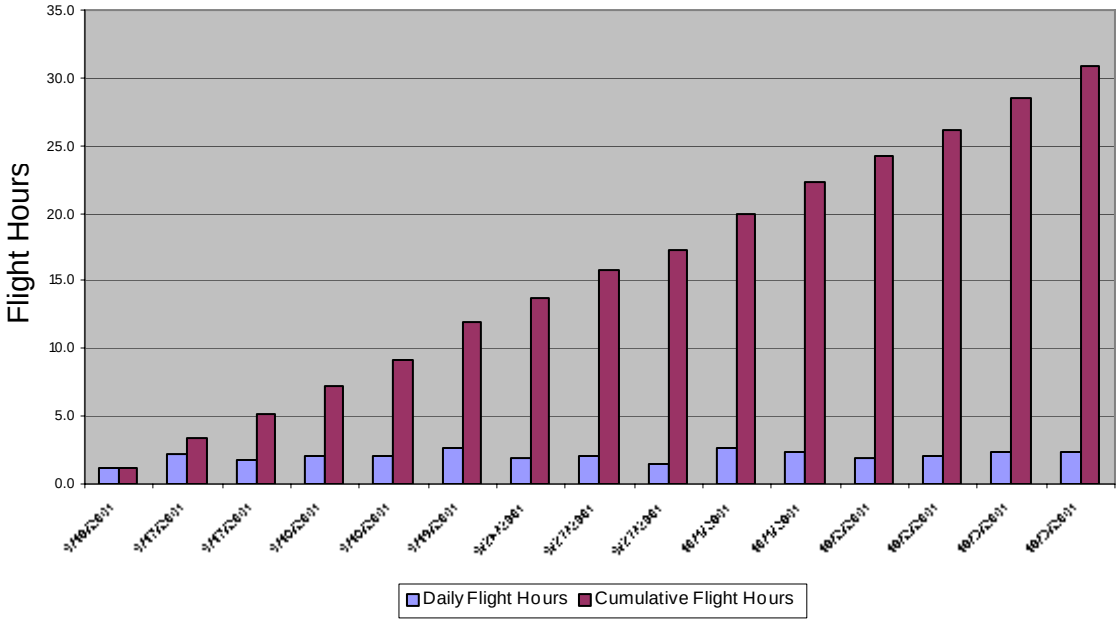


FIGURE 7. EATON FLIGHT TEST HOURS

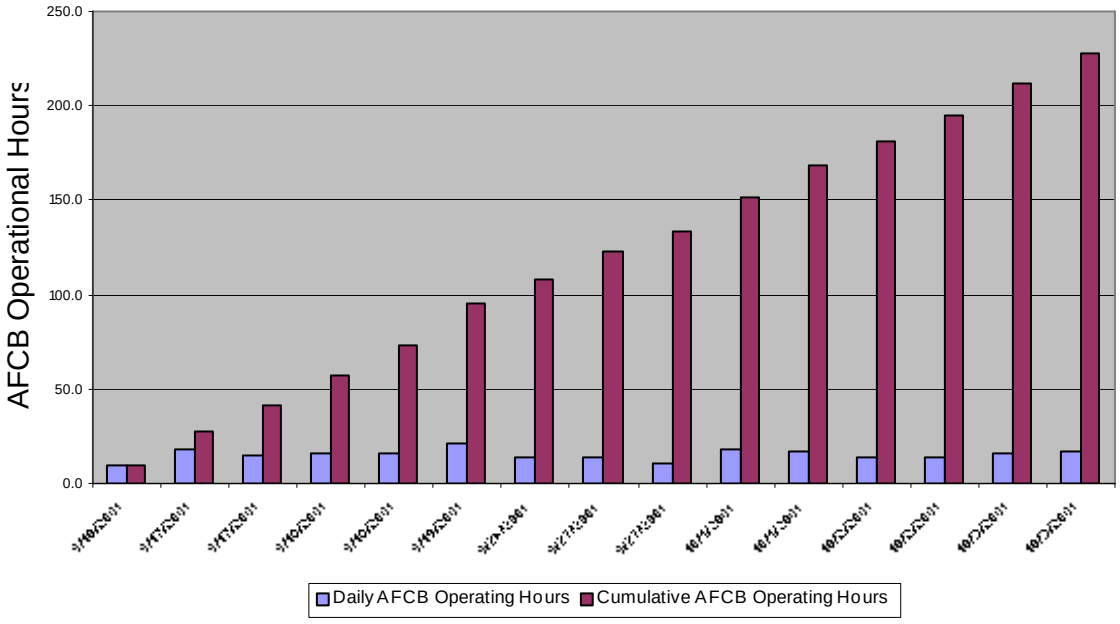


FIGURE 8. EATON AFCB OPERATING HOURS

3.2 HENDRY FLIGHT TEST STATISTICS.

Figures 9 and 10 contain the summarized Hendry flight test data. Figure 9 shows the flight hour data, and figure 10 shows the cumulative AFCB operational hours. The Hendry AFCBs

accumulated 88.0 flight hours and 701.5 operational hours. Appendix D contains the detailed data on the flights.

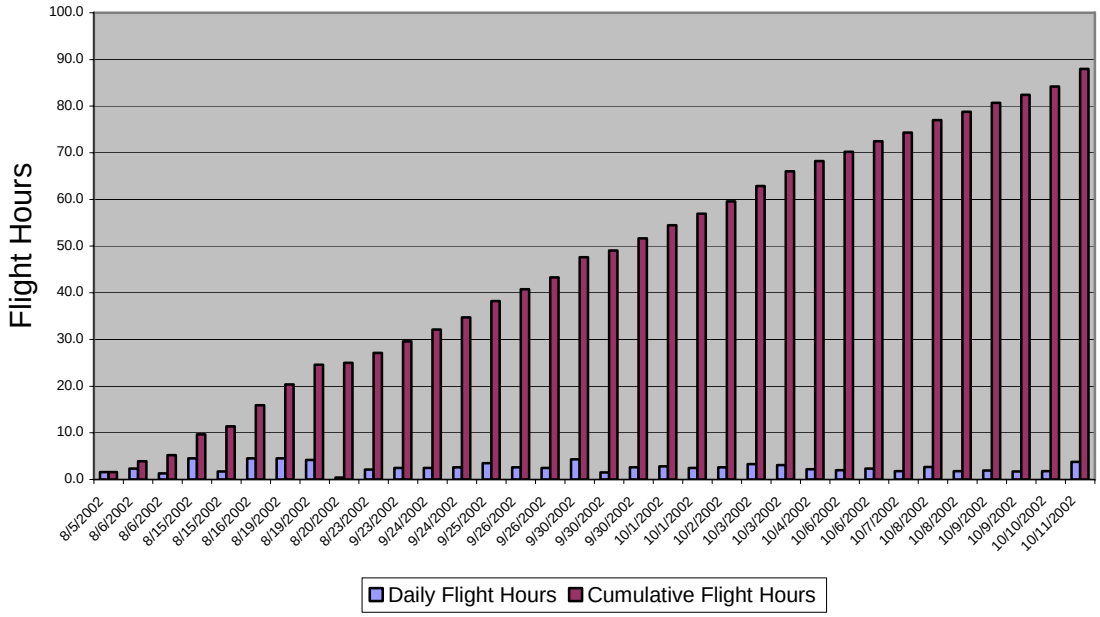


FIGURE 9. HENDRY FLIGHT TEST HOURS

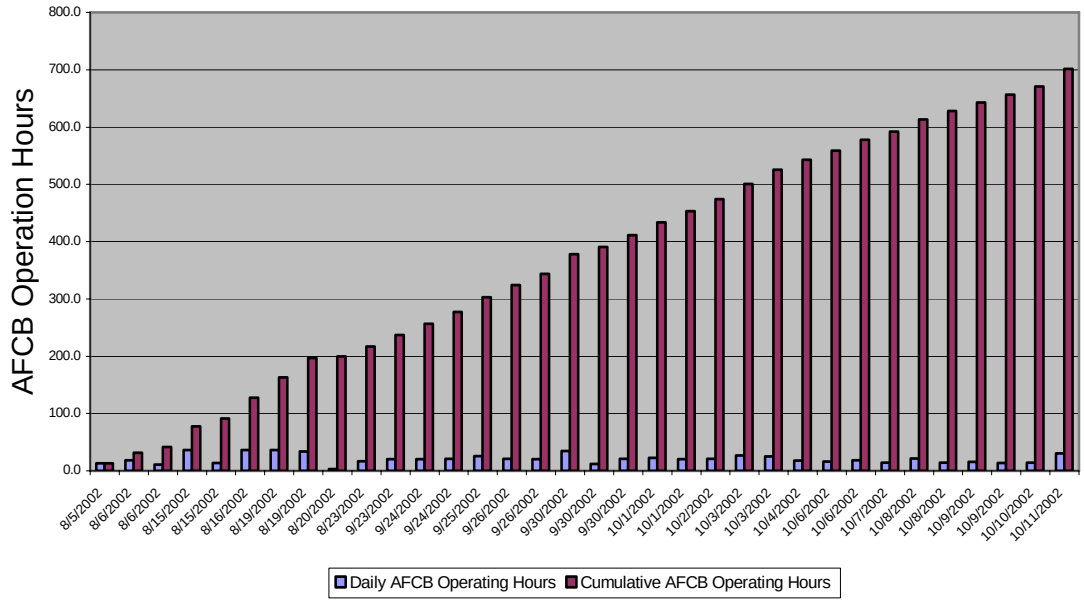


FIGURE 10. HENDRY AFCB OPERATING HOURS

Initial bench testing (guillotine tests), aircraft installation, and debug flight-testing were conducted between 19 June 2002 and 2 July 2002 with test AFCBs not in a common algorithm configuration. At the conclusion of these tests, it was decided that flight-testing would not be

started until all eight installed AFCBs were of the same configuration (amp rating excepted). The circuit breakers were sent to Hendry for rework and returned to the FAA on 31 July 2002 for reinstallation and flight-testing. During this time frame, the Odyssey recorder was returned to the manufacturer for an 8-channel upgrade (to 32 channels total) and warranty replacement (a digital signal processor chip on the other signal processing boards). The flight test commenced on 5 August 2002. A second gap in consecutive flight test time occurred between 24 August and 22 September 2002 when the aircraft experienced a fuel tank leak. Flying resumed on 23 September and continued until 11 October 2002. During this period, the flight profile included approximately 120 approaches. At this point, the aircraft was removed from experimental status to support other scheduled FAA R&D flight test programs, and the Hendry flight test program was completed.

4. SAMPLE DATA RECORDINGS.

Figures 11 through 14 are waveform examples that can be expected during normal operation of aircraft equipment and must be accounted for in the algorithms incorporated in an AFCB. The waveforms were obtained during the course of this flight test program and were recorded with the Nicolet data recorder.

Figure 11 shows an example of the voltage waveforms encountered during a power transfer from APU to engine.

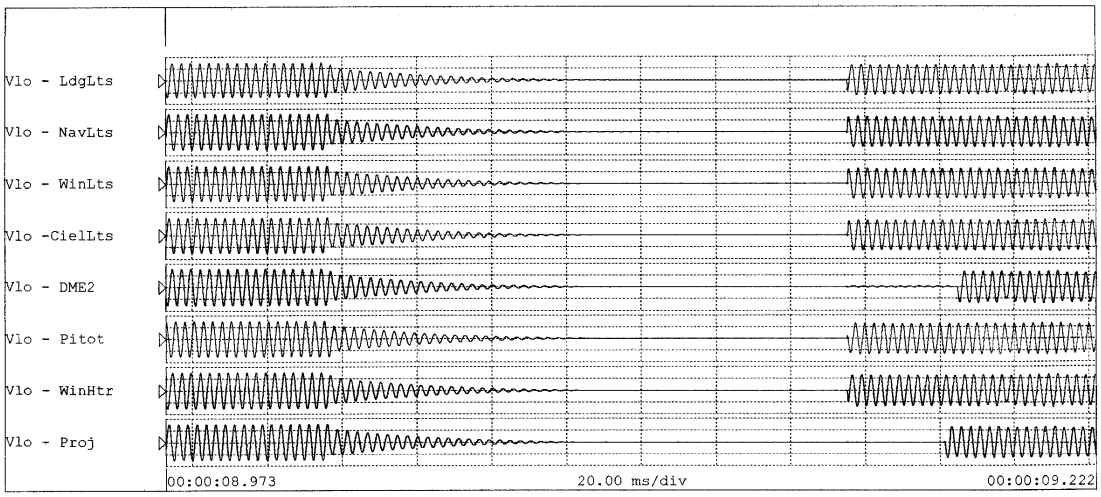


FIGURE 11. AUXILARY POWER UNIT-TO-ENGINE POWER TRANSFER TRANSIENT WAVEFORM

Start-up current transients can often be many times the rated current of the circuit breaker. The transient current is one factor that most arc-fault detection algorithms monitor. Examples of typical cabin ceiling light transient current are shown in figure 12. Peak current on the cabin ceiling lights was 42 A, nearly three times the rated current of the circuit.

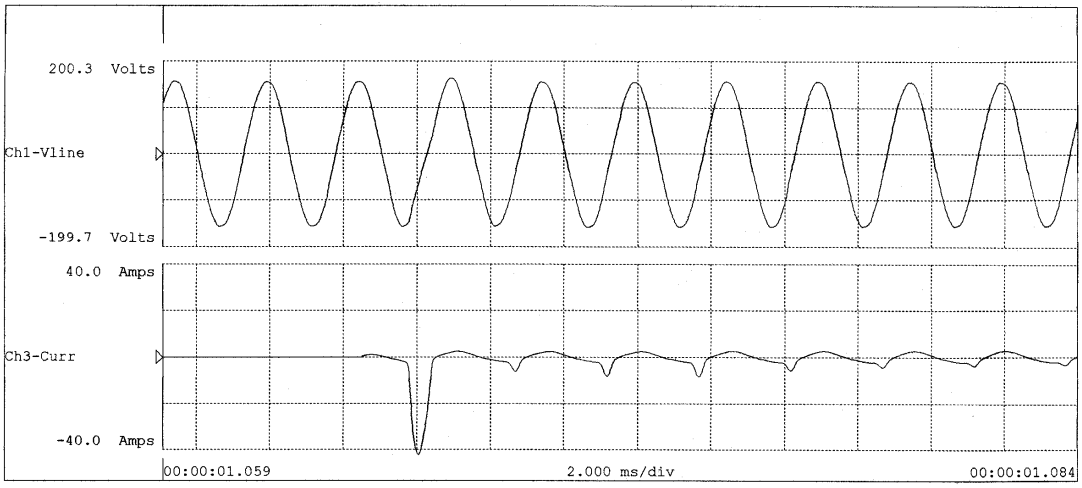


FIGURE 12. CABIN CEILING LIGHT TURN-ON TRANSIENT WAVEFORM

Inboard landing light start-up transients are shown in figure 13. The peak in-rush current on the inboard landing light was 46 A, more than six times the rated current of the AFCB.

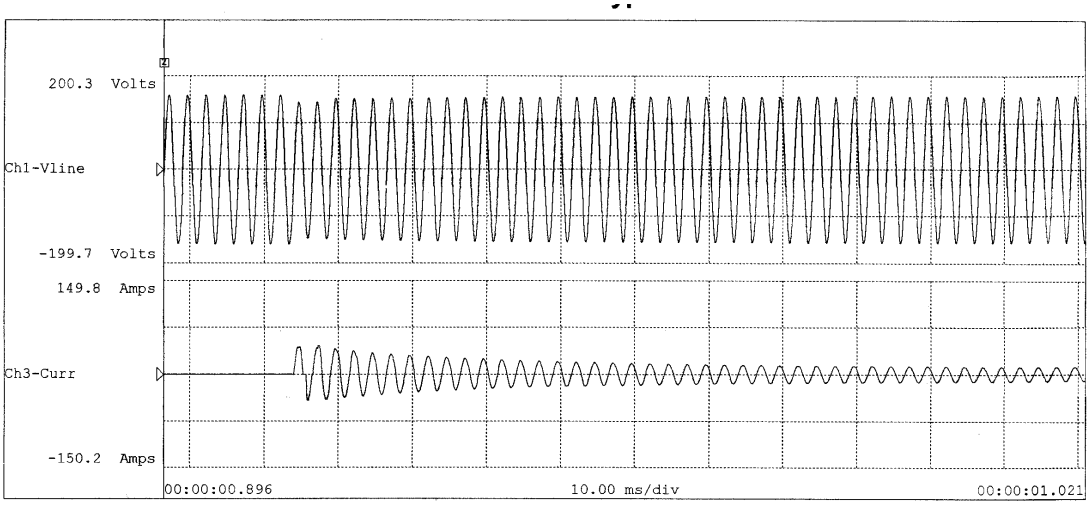


FIGURE 13. LANDING LIGHT IN-RUSH CURRENT WAVEFORM

Figure 14 shows an example of a guillotine (dry-arc) arc-fault test. Note again, the high-current transients over 100 A. This test was conducted on each AFCB prior to installation to verify the functionality of the arc detection and trip circuitry. In this particular test, the first trigger occurred within two cycles of the guillotine. Current shutdown occurred within one-half cycle of the trigger. Current is only limited by the source impedance and the wire characteristics between the source and the fault.

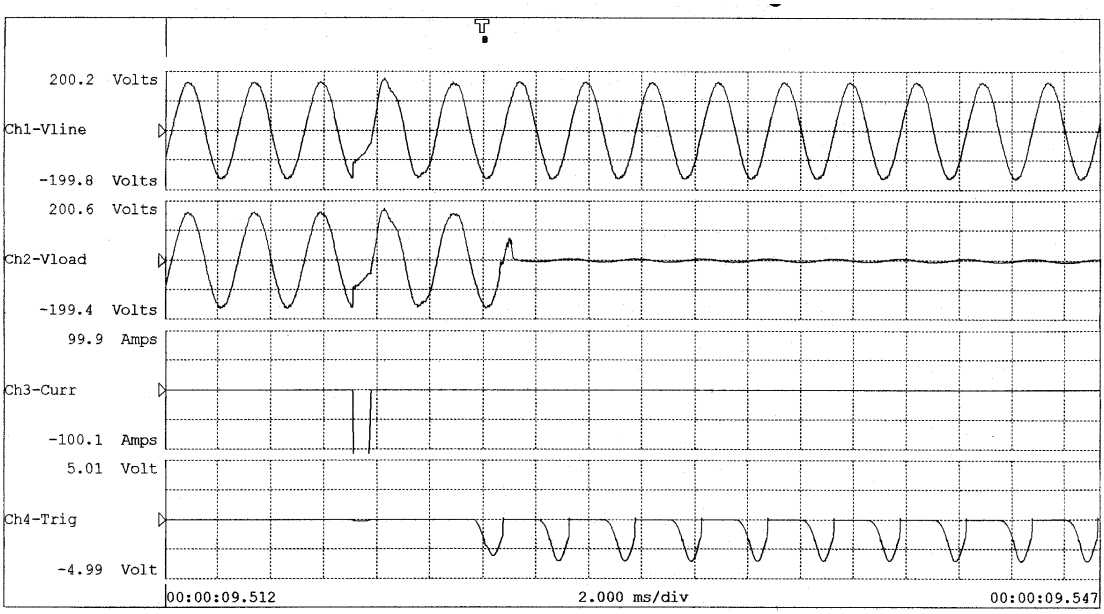


FIGURE 14. GUILLOTINE (DRY-ARC) ARC-FAULT TEST WAVEFORM

5. FLIGHT TEST.

5.1 EATON FLIGHT TEST PLAN.

5.1.1 Introduction.

The FAA William J. Hughes Technical Center R&D flight test program performed a minor modification to their B-727-25C aircraft. This temporary modification involved the installation of eight AFCB prototypes manufactured by Eaton Aerospace Controls. The AFCBs were installed for a 2-week experimental flight test period in support of AFCB R&D.

The AFCBs were installed in an AFCI-JB that enclosed all the AFCBs and required instrumentation. The AFCBs were not mounted in the aircraft circuit breaker panels. It is important to note that the AFCBs were connected in series with the load side of the existing thermal circuit breakers. In other words, current circuit protection aboard the aircraft was not compromised in any way by this installation.

The electrical, system, and mechanical integration of this installation was accomplished at Atlantic City International Airport using FAA technical and engineering personnel. The New York Aircraft Certification Office granted the engineering personnel authority to approve electrical systems and structures data via FAA Form 8110-3.

It is important to note that no arc faults will be created in the aircraft. The purpose of the flight-testing is to evaluate nuisance tripping only. Arcing will not intentionally be created aboard the aircraft in flight or on the ground. The Eaton Flight Test Plan is shown in appendix B.

5.1.2 Flight Test Goals.

The following list describes the goals of the experimental flight test program, listed in order of importance.

- Complete at least 50 (or more) flight hours but not less than 25 hours. Data generated during these flights is critical to the AFCB R&D program and for obtaining approval of the N40 one-only supplemental type certificate (STC).

- Evaluate the operation of the AFCBs under standard B-727 operational procedures.

- Evaluate the operation of the AFCB instrumentation and Odyssey data recording system for future unmanned data collection.

5.1.3 System Description.

The AFCB installation consists of the following:

- Eight Eaton prototype AFCBs of the following ratings: two 5 A, three 7.5 A, one 10 A, and two 15 A (mounted in the AFCI-JB).

- One AFCI-JB

- Two AFCI-JB test unit wire harnesses, P18 and P6

- One 24-channel Nicolet odyssey data recorder

- One BNC breakout box

- One AFCI-JB—BNC breakout box interface harness

- Twenty-four 36-inch BNC connector cables

- One trigger alarm

The AFCI-JB contained the eight AFCB units. The test unit was mounted in the rear, left side of the cockpit. The test unit has bypass switches that disable the AFCBs if desired. The test unit was fabricated using standard best practices and in accordance with AC 43.13-1B and contain any possible AFCB failure.

The electrical connections for the system are shown schematically in appendix K. The AFCBs mounted within the AFCI-JB were electrically in series with the load side of the existing circuit breakers. The AFCI-JB wire harnesses, P-18 and P-6, connect the load side of the each aircraft circuit breaker to the line side of the respective AFCB and from the load side of the each AFCB to the feed wire for the respective load.

The BNC breakout box and the Odyssey data recorder were mounted in the cabin of the aircraft. The AFCI-JB/BNC breakout box interface harness connects the AFCI-JB to the BNC breakout box.

The 24 BNC connectors on the BNC breakout box are connected to the Odyssey data recorder with 36-inch BNC coaxial cables.

Detailed installation instructions are provided in the AFCB Ground Test Checkout Procedures in appendix C.

5.1.4 Certification Requirements.

There are no FAA technical standard orders for the equipment installed during this modification. Experimental flight test was performed to collect data necessary to obtain a one-only STC to install the AFCBs aboard N40 for an extended evaluation period.

5.1.5 Flight Test Profile Requirements.

N40 was operated in conformance with standard B-727 operations. The purpose of the flight test is to maximize the number of flight hours. Duration and distance of flights was at the discretion of the pilot in command and within the operating restrictions established by the Manufacturing Inspection District Office (MIDO).

No excessive cycling of the aircraft is necessary.

As established by the MIDO, flight restrictions were removed to the maximum extent possible upon completion of flight hour thresholds established by the MIDO.

5.1.6 Limitations.

It was proposed that the first 10 flight hours (phase 1) be conducted within a 50-mile radius from Atlantic City International Airport. Upon satisfactory completion of this 10-hour period, it was requested that the remainder of the flights be conducted without restrictions (phase 2).

An ACT-370 Safety Officer was on all phase 1 flights.

An FAA engineer (or designee) had to be aboard the aircraft during all AFCB flight tests to operate the Odyssey data recorder.

No AFCB-equipped circuit was to be operated in flight after an AFCB trip on the circuit, unless the pilot in command orders the operation of the circuit during an emergency. In this case, the flight engineer has to switch the associated bypass switch on the AFCI-JB to the bypass position. In addition, after an AFCB trip, the flight engineer shall pull the associated circuit breaker on the aircraft circuit breaker panel. Troubleshooting shall be performed in accordance with the AFCB Troubleshooting Procedures in appendix E.

If there are two or more AFCB trips on a single electrical bus, the flight test shall be terminated and the aircraft will return to the base immediately.

5.1.7 Emergency Procedures.

In the event of an emergency (related or unrelated to the AFCB testing), the following procedures had to be followed if ordered by the pilot in command.

The flight engineer shall bypass all the AFCBs by closing the AFCB bypass switches on the AFCB-JB located behind the captain's chair.

- The flight engineer will set each AFCB to the open position.
- The engineer operating the system will power off the Odyssey data recorder.

If power must be removed from the AFCB-JB, the following steps will be completed:

- The flight engineer will open the eight circuit breakers on the aircraft circuit breaker panels. A colored button or other tag will uniquely identify these breakers. The eight circuit breakers and their respective locations are summarized in table 1.

TABLE 1. EATON AFCB TEST CIRCUIT BREAKER LOCATIONS

AFCB No.	Circuit Breaker Identity	Panel/Location	Rating (A)	Bus
1	Left Inboard Landing Lights	P18-4 Lighting	7	115 Vac Bus No. 1
2	Navigation Lights	P18-4 Lighting	5	115 Vac Bus No. 2
3	Window Lights	P18-3 Lighting and Passenger Accommodations	10	115 Vac Transfer Bus
4	Left Ceiling Lights	P18-3 Lighting and Passenger Accommodations	15	115 Vac Transfer Bus
5	DME-2	P18-3 Electronic Load Circuit Breaker	3	115 Vac Radio Bus No. 2
6	Heater-Pitot-Aux	P6-1 Miscellaneous ac, Anti-Ice and Rain	5	115 Vac Bus No. 2
7	First Officers Window 4 & 5	P6-1 Miscellaneous ac, Anti-Ice and Rain	5	115 Vac Bus No. 3
8	Project Power	Project Power Junction Box	10	115 Vac Bus No. 2

5.1.8 Normal Procedures.

5.1.8.1 Preflight.

- Review flight plan with flight crew and all passengers.

- Review emergency procedures with flight crew and all passengers.

- Review all normal procedures with flight crew and all passengers.
- Flight engineer set all bypass switches on the AFCI-JB to normal.
- Apply power to the aircraft (ground power or APU).
- Flight engineer open AFCB-1, AFCB-2, AFCB-3, AFCB-4, AFCB-6, and AFCB-7. Close AFCB-5 and AFCB-8.
- Turn Odyssey data recorder to ON and wait for system to boot up and initialize. Start recording. Note the date, time, and recording number.
- Flight engineer close AFCB-1, AFCB-2, AFCB-3, AFCB-4, AFCB-6, and AFCB-7 on the AFCI-JB.
- If on ground power, start APU. Start Odyssey data recording and instruct flight engineer to transfer power from ground power to APU power. Stop data recording as soon as power transfer is complete. Record the date, time, and file name of the recording in the test logbook. Note that the recording was a ground power to APU transfer.
- If on APU power, start aircraft engines. Start Odyssey data recording and instruct flight engineer to transfer power from APU to engine generators. Stop data recording as soon as power transfer is complete. Record the date, time, and file name of the recording in the test logbook. Note that the recording was an APU to engine generator power transfer.
- Start the Odyssey data recording. Data will be recorded at the slow rate, 1 kHz. Note the date, time, and file name in the test logbook. Also note the general conditions (weather, etc.) at this time.
- Proceed to flight phase in accordance with standard B-727 start-up procedures.

5.1.8.2 Flight.

- Monitor Odyssey data recording system. The visual and aural trigger alarm mounted adjacent to the Odyssey data recorder will initiate when an AFCB has tripped and the Odyssey data recorder will automatically begin recording at the high sampling rate (100 kHz).
- If the trigger alarm sounds, depress the red reset button mounted on the trigger alarm enclosure to silence the trigger and extinguish the trigger alarm lights.
- Stop the data recording and start a new data recording file.
- Note the date, time, and the number of the AFCB(s) that caused the trigger. Also note the flight conditions and other information pertinent to the trigger event in the test logbook. Also note the new file name in the logbook with the start time of the recording.

5.1.8.3 Postflight.

- Continue to follow the flight procedures.
- Prior to engine shutdown, start APU or apply ground power. Switch aircraft power to APU or ground power. Shut engines in accordance with standard B-727 operational procedures.
- Shutdown the Odyssey data recorder.
- Shutdown aircraft in accordance with standard B-727 operational procedures.

5.2 EATON DISCREPANCIES.

The Eaton circuit breakers did not experience any nuisance trips during the flight test program. There were two AFCB discrepancies. In both cases, the units failed to latch in the closed position. These units were sent to Eaton for evaluation.

5.2.1 Discrepancy 1.

- Problem Reported: The 10-A AFCB will not latch when the button is in the set position and no power is applied to the breaker.
- Initial Investigation: Discrepancy confirmed.
- Actions Taken for Investigation: The potting was removed from the calibration screw. After backing off the calibration screw, the problem continued. Next, the unit's potting was removed, and the unit was opened, but the problem continued. The electronics were then removed from the device. During the inspection of the mechanical side of the breaker, a problem was noted. The brazed area that attaches the bimetal to the terminal had broken. This caused the bimetal to pull away from its calibrated position preventing the unit from latching.
- Corrective Action: In the brazing process, the bimetal was established by a bend in the bimetal foot prior to brazing to the buss bar or the terminal. It was discovered that the angle of the bimetal foot to the terminal made it difficult to transfer the heat properly and form a complete braze joint. The bimetal angle was modified, allowing the brazing fixture to make full contact across the bimetal foot for better heat transfer. The prototype flight test units delivered to the FAA were all constructed using the old brazing process. All flight test units delivered to the U.S. Navy were constructed using the new brazing process. The U.S. Navy units did not experience this problem, indicating a successful resolution of the problem. It is also important to note that all the units were prototypes, built substantially by hand and not representative of the manufacturing processes that will ultimately be used when the units are in full production.

5.2.2 Discrepancy 2.

- Problem Reported: 7.5-A AFCB failed to latch after an initial trip during the power-up. The flight crew removed the trigger wire from its connector to investigate why the unit would not stay closed. During their investigation, the flight crew noticed a spark when the trigger signal wire touched the grounded portion of the AFCI-JB. After the spark, the flight crew measured 115 VRMS on the signal wire and disabled the circuit breaker.

- Initial Investigation: Discrepancy confirmed.

- Actions Taken for Investigation: The potting was removed from the calibration screw. After backing off the calibration screw, the problem continued. Next, the unit's potting was removed, and the unit was opened, but the problem continued. The electronics were then removed from the device. In the inspection of the electronics power board, the silicone control rectifier (SCR) had been destroyed, indicating a high in rush of current. The coil of the device was still intact, indicating an alternative current path. During the inspection of the mechanical side of the breaker, a problem was noted. The brazed area that attaches the bimetal to the terminal had broken. This caused the bimetal to pull away from its calibrated position, preventing the unit from latching.

- Corrective Action: The initial cause of the problem was the same as the 10-A AFCB (a broken braze on the bimetal). This condition caused the breaker to receive a trip signal from the electronics. The trip signal wire touching the airframe provided an unrestricted source of current, which damaged the SCR. In production of AFCBs, the trigger signal wire will not be present. The FAA AFCI-JB will be redesigned to monitor trip current without requiring a trigger signal wire for the AFCB. The proposed method will be to monitor current on the ground connection for a large current spike, which would indicate the trip coil had been fired.

The Eaton testing was completed prior to the instrumentation modifications. However, the instrumentation changes were completed prior to the Hendry testing.

5.3 EATON TROUBLESHOOTING PROCEDURES.

5.3.1 Arc-Fault Troubleshooting Background.

Although AFCBs can detect arcing on the circuit in which it is installed, it cannot determine the location of the arc along the circuit. Furthermore, means for easily troubleshooting an arc fault after an AFCB trip are under development but not currently available. This plan has been developed to establish a procedure for troubleshooting AFCB trips, should they occur.

An understanding of current methods of troubleshooting thermal trips will clarify the additional measures needed to troubleshoot an AFCB trip and specifically the procedures that will be followed during the FAA AFCB flight test program.

Troubleshooting circuit breakers is an iterative process. Generally, after a thermal circuit breaker trip, troubleshooting begins by evaluating the load(s) powered by the circuit. The load is

either tested for correct operation or is removed and replaced if its correct operation cannot be directly determined. The circuit is powered, and if no additional trips are noted, the corrective action is considered complete. If additional trips of the same circuit occur, there are several options for corrective action. The load may still be suspected, and the problem may not be reproducible on the ground. The circuit breaker itself may be suspect and replaced (tripping of thermal circuit breakers under normal conditions or failure of a circuit breaker to stay closed when depressed, are two common circuit breaker failure modes). Usually, the last item to be checked is the circuit wiring, mainly because of the inherent difficulties in testing and inspecting the wiring.

AFCBs add another dimension of complexity to the troubleshooting problem. AFCBs have two trip modes, thermal (current overload) and arc fault. There are unique procedures for troubleshooting each mode, and unfortunately, if one procedure fails to identify the problem, it may be necessary to complete the other procedure to be certain that the problem has been resolved. Future AFCBs will have the ability to indicate if the trip mode was thermal- or arc fault-related. The prototypes flown in this test program will not have this feature. However, the data recording instrumentation will be triggered by the AFCBs arc-fault detection circuit and, therefore, it will be known with certainty if the trip mode was thermal versus arc fault.

If the trip mode was arc-fault related, the question remains, Was the arc trip a real arc or was it a nuisance trip? The instrumentation being used in these flights will record the current waveforms immediately before and after the AFCB indicates that an arc is present and a trip is initiated. This data will be analyzed by Eaton to determine if it appears to be a real arc or a nuisance trip. If it is certain that the trip was nuisance-related, then the breaker will be reset and flight-testing may resume. If a nuisance trip is not certain, then further diagnostics will be required.

Provisions have been made to baseline the condition of the wiring on the eight circuits that will be used in the tests with TDR. During ground testing of the AFCB test system, each AFCB-equipped circuit will be characterized with TDR. This data will form a baseline measurement against which future measurements will be compared. Changes in the measurement indicate possible locations at which the arcing may have occurred.

At this point, it is unclear if TDR is sensitive enough to detect the damage incurred by a wire during an arcing condition. If the TDR fails to identify the location of the fault, visual inspection of the circuit must be performed to determine the source of the fault.

5.3.2 Detailed Troubleshooting Procedures.

Qualified FAA personnel under the direction of the Electrical Systems Designated Engineering Representative, ACT-370, performed all troubleshooting. Upon an AFCB arc-fault trip, the Odyssey data recording system will record the current and voltage waveforms from the eight circuits equipped with AFCBs. A thermal trip of the AFCB or the aircraft circuit breaker will not cause the Odyssey to trigger on and record this data. Therefore, it will be known immediately if the trip was caused by an arc fault.

5.3.3 Detailed Process Flow Chart.

Figure 15 shows a detailed process flow chart for the Eaton AFCB.

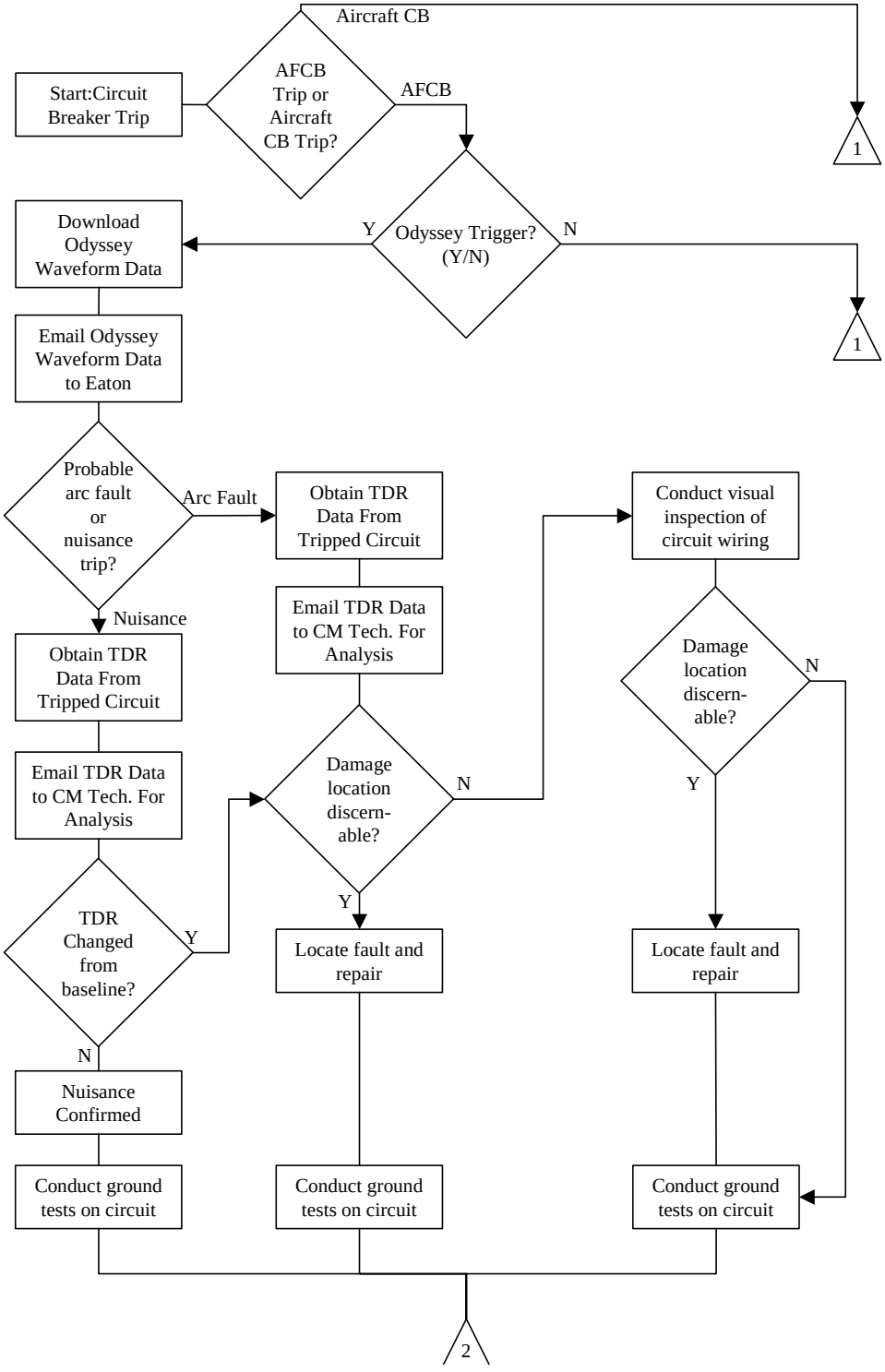


FIGURE 15. EATON DETAILED PROCESS FLOW CHART

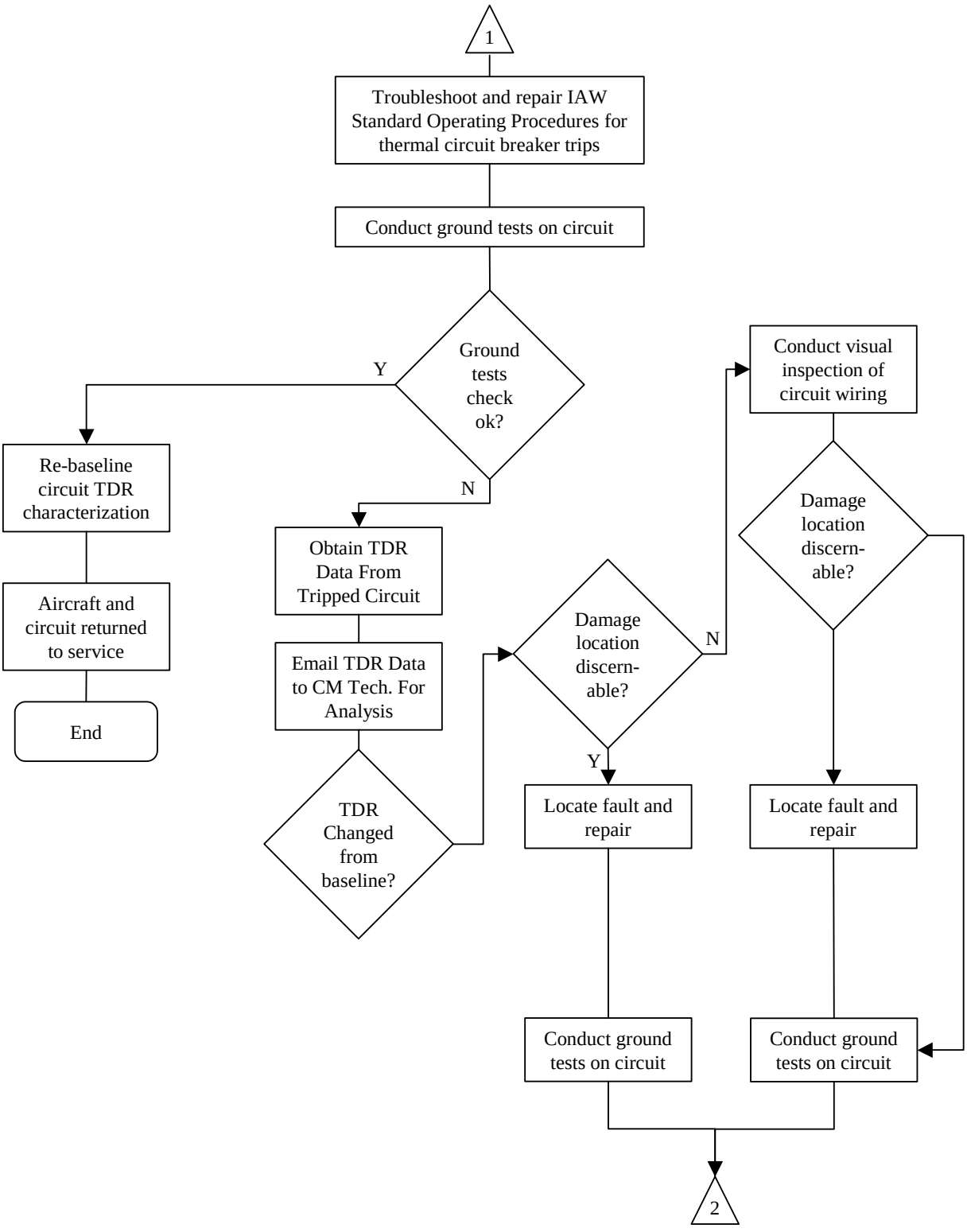


FIGURE 15. EATON DETAILED PROCESS FLOW CHART (Continued)

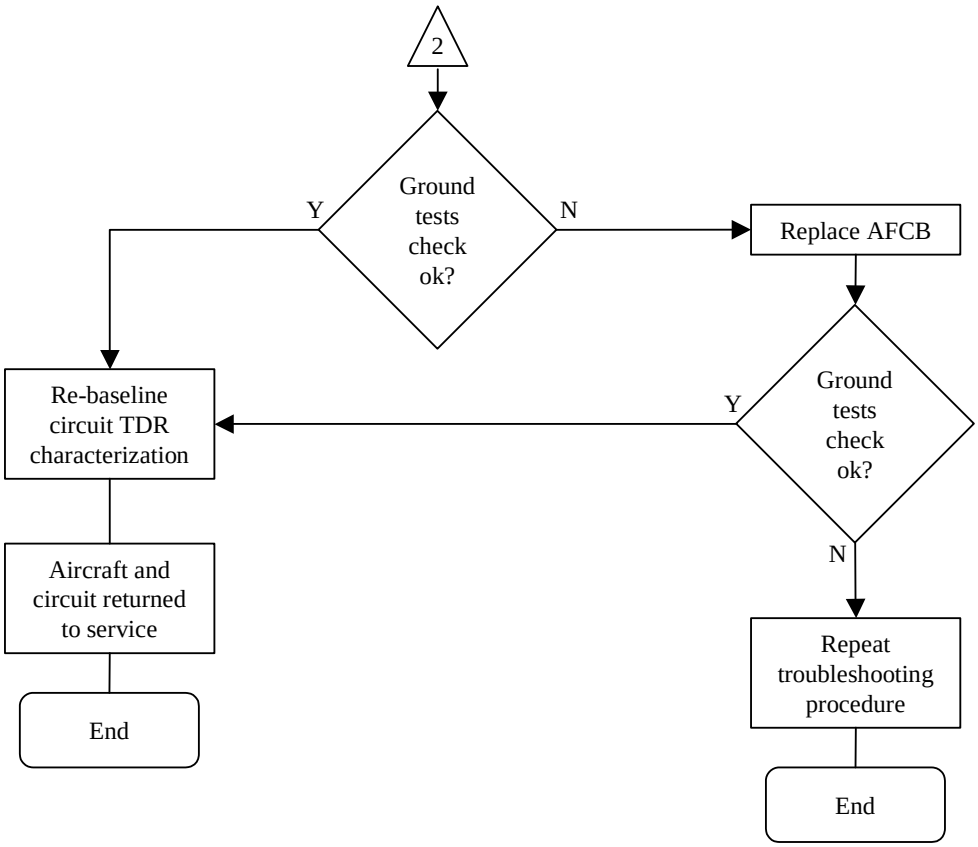


FIGURE 15. EATON DETAILED PROCESS FLOW CHART (Continued)

5.4 HENDRY TEST PLAN.

5.4.1 Introduction.

This test plan defines the flight test procedures for evaluating the performance of AFCBs in an FAA-owned B-727-25C aircraft. The effort was conducted at the FAA William J. Hughes Technical Center.

5.4.2 Objective.

The objective of this task was to conduct an in-flight evaluation of AFCB performance.

The FAA William J. Hughes Technical Center R&D Flight Program performed a minor modification to their B-727-25C aircraft. This temporary modification involved the installation of eight AFCB prototypes manufactured by the Hendry Corporation. The AFCBs were installed for a 6-month evaluation period in support of AFCB R&D.

5.4.3 Scope.

The scope of this effort was to install AFCBs manufactured by the Hendry Corporation in an FAA-owned B-727-25C aircraft and conduct a flight evaluation of the developmental AFCBs. Data recorded included line voltage, load voltage, and current for each of the installed breakers. Data reduction efforts of any occurring arc faults will include identification of relationships between the trip conditions.

5.4.4 Flight Test Goals.

The following list describes the goals of the experimental flight test program, listed in order of importance.

- Complete 50 or more hours of developmental flight test evaluation but not less than 25 hours. Data generated during these flights is critical to the AFCB R&D program and for obtaining approval of the N40 one-only STC.

- Evaluate the operation of the AFCBs under standard B-727 operational procedures.

- Evaluate the operation of the AFCB instrumentation and Odyssey data recording system for future unmanned data collection.

The complete flight records for Hendry flight test are shown in appendix H.

5.4.5 System Description.

The equipment installed for the arc-fault flight evaluation included developmental prototype AFCBs installed in a junction box, an instrumentation recorder and interconnecting cables, and wire harnesses. These items are described in the following sections.

5.4.5.1 Arc-Fault Circuit Breakers.

Eight Hendry prototype AFCBs of the following ratings: one 2.5 A, three 5 A, one 7.5 A, one 10 A, and two 15 A (mounted in the AFCI-JB).

5.4.5.2 Arc-Fault Circuit Interrupter-Junction Box and Aircraft Harnesses.

- One AFCI-JB
- Two AFCI-JB Test Unit wire harnesses, P18 and P6

5.4.5.3 Instrumentation Equipment.

- One 24-channel Nicolet Odyssey data recorder
- One BNC Breakout Box
- One AFCI-JB BNC breakout box interface harness
- Twenty-four 24-inch BNC connector cables
- One Trigger Alarm

5.4.5.4 Aircraft Interfaces.

The electrical connections for the system are shown schematically in appendix K. The AFCBs mounted within the AFCI-JB were electrically in series with the load side of the existing circuit breakers. The AFCI-JB wire harnesses, P-18 and P-6, connected the load side of the each aircraft circuit breaker to the line side of the respective AFCB and from the load side of the each AFCB to the feed wire for the respective load.

It is important to note that the AFCBs were connected in series with the load side of the existing thermal circuit breakers. In other words, current circuit protection aboard the aircraft was not compromised in any way by this installation.

The onboard Project Power Inverter provided 120-Vac, 60-Hz power for the data acquisition system.

5.4.6 Aircraft Installation.

The AFCBs were installed in an AFCI-JB that enclosed all the AFCBs and required instrumentation interfaces. The AFCI-JB was mounted in the rear, left side of the cockpit. The test unit had bypass switches that would disable the AFCBs if desired.

The BNC breakout box and the Odyssey data recorder were mounted in the cabin of the aircraft.

The electrical installation was completed in accordance with drawing number 9854415 under the guidance of the William J. Hughes Technical Center Electrical Systems Designated Engineering Representative.

Detailed instructions for completing the installation can be found in the AFCB Hendry Ground Checkout Procedures Report in appendix G.

5.4.7 Certification Requirements.

There were no FAA Technical Standard Orders for the equipment being installed during this modification. Experimental flight tests were performed to collect data necessary to obtain a one-only STC to install the AFCBs aboard N40 for an extended evaluation period.

5.4.8 Flight Test Profile Requirements.

N40 was operated in conformance with standard B-727 operations. The purpose of the flight test was to maximize the number of flight hours. The duration and distance of the flights were at the discretion of the pilot in command and within the operating restrictions established by the MIDO. The Hendry Flight Test Plan is shown in appendix F.

No excessive cycling of the aircraft was necessary.

As established by the MIDO, flight restrictions shall be removed to the maximum extent possible upon completion of flight hour thresholds established by the MIDO.

5.4.9 Limitations.

It was proposed that the first five flight hours (phase 1) be conducted within a 100-mile radius from Atlantic City International Airport. Upon satisfactory completion of this 5-hour period, it was requested that the remainder of the flights be conducted without restrictions (phase 2).

An ACT-370 safety officer was on all phase 1 flights.

An FAA engineer (or designee) had to be aboard the aircraft during all AFCB flight tests to operate the Odyssey data recorder.

No AFCB-equipped circuit was operated in flight after an AFCB trip on the circuit, unless the pilot in command ordered the operation of the circuit during an emergency. In this case, the flight engineer had to switch the associated bypass switch on the AFCI-JB to the bypass position. In addition, after an AFCB trip, the flight engineer had to pull the associated circuit breaker on the aircraft circuit breaker panel. Troubleshooting had to be performed in accordance with the AFCB Troubleshooting Procedures.

If there are two or more AFCB trips on a single electrical bus, the flight test was terminated, and the aircraft returned to the base immediately.

5.4.10 Emergency Procedures.

In the event of an emergency (related or unrelated to the AFCB testing), the following procedures had to be followed if ordered by the pilot in command.

- The flight engineer shall bypass all AFCBs by closing the AFCB bypass switches on the AFCI-JB located behind the captain's chair.

- The flight engineer will set each AFCB to the open position.

- The engineer operating the system will power off the Odyssey data recorder.

If power must be removed from the AFCI-JB, the following steps will be completed:

- The flight engineer will open the eight circuit breakers on the aircraft circuit breaker panels. A colored button or other tag will uniquely identify these breakers. The eight circuit breakers and their respective locations are summarized in table 2.

TABLE 2. HENDRY AFCB TEST CIRCUIT BREAKER LOCATIONS

AFCB Circuit No.	Circuit Breaker Identity	Panel/Location	Rating (A)	Bus
1	Left Inboard Landing Lights	P18-4 Lighting	7	115 Vac Bus No. 1
2	Navigation Lights	P18-4 Lighting	5	115 Vac Bus No. 2
3	Window Lights	P18-3 Lighting and Passenger Accommodations	10	115 Vac Transfer Bus
4	Left Ceiling Lights	P18-3 Lighting and Passenger Accommodations	15	115 Vac Transfer Bus
5	DME-2	P18-3 Electronic Load Circuit Breaker	3	115 Vac Radio Bus No. 2
6	Heater-Pitot-Aux	P6-1 Miscellaneous ac, Anti-Ice and Rain	5	115 Vac Bus No. 2
7	First Officers Window 4 & 5	P6-1 Miscellaneous ac, Anti-Ice and Rain	5	115 Vac Bus No. 3
8	Project Power	Project Power Junction Box	10	115 Vac Bus No. 2

5.4.11 Normal Procedures.

5.4.11.1 Preflight.

- Review flight plan with flight crew and all passengers.
- Review emergency procedures with flight crew and all passengers.
- Review all normal procedures with flight crew and all passengers.
- Flight engineer will set all bypass switches on the AFCI-JB to normal except S8 (leave in BYPASS) and S1. Leave S1 in BYPASS until landing light is on, and then switch S1 to NORMAL.
- Apply power to the aircraft (ground power or APU).
- Flight engineer closes all AFCBs.
- Turn Odyssey data recorder to ON and wait for system to boot up and initialize. Start recording. Note the date, time, and recording number.
- If on ground power, start APU. Start Odyssey data recording and instruct flight engineer to transfer power from ground power to APU power. Record the date, time, and file name of the recording in the test logbook. Note that the recording was a ground power to APU transfer.
- If on APU power, start aircraft engines. Continue Odyssey data recording and instruct flight engineer to transfer power from APU to engine generators. Record the date, time,

and file name of the recording in the test logbook. Note that the recording was an APU to engine generator power transfer.

- Continue the Odyssey data recording. Data will be recorded at the slow rate, 1 kHz. Note the date, time, and file name in the test logbook. Also, note the general conditions (weather, etc.) at this time.

- Proceed to flight phase in accordance with standard B-727 start-up procedures.

5.4.11.2 Flight.

- Monitor Odyssey data recording system. The visual and aural trigger alarm mounted adjacent to the Odyssey data recorder will initiate when an AFCB has tripped and the Odyssey data recorder will automatically begin recording at the high sampling rate, 100 kHz.

- If the trigger alarm sounds, press the red reset button mounted on the trigger alarm enclosure to silence the trigger and extinguish the trigger alarm lights.

- Note the date, time, and the number of the AFCB(s) that caused the trigger. Also note the flight conditions and other information pertinent to the trigger event in the test logbook, as well as the new file name with the start time of the recording.

5.4.11.3 Postflight.

- Continue to follow the flight procedures.

- Prior to engine shutdown, start APU or apply ground power. Switch aircraft power to APU or ground power. Shut engines in accordance with standard B-727 operational procedures.

- Download data files from the Odyssey data recorder.

- Shutdown the Odyssey data recorder.

- Shutdown aircraft in accordance with standard B-727 operational procedures.

5.5 HENDRY DISCREPANCIES.

After correction of discrepancies discovered during initial ground integration and debug flight test and establishment of a common baseline configuration (amp rating excepted) for all test breakers, the Hendry circuit breakers still experienced multiple instrumentation trigger and circuit breaker trip occurrences during the flight test program. There were two distinct categories of recurring AFCB discrepancies. In both cases, a work around was developed to allow the flight test program to continue. Additionally, there were three other trip occurrences during the flight test program that could be considered nuisance trips. The corrective actions, though labeled undetermined, will be addressed on the follow-on phase of this research project.

5.5.1 Discrepancy 1.

- Problem Reported: The circuit breakers would provide a false instrumentation trigger output during power transfers, indicating a circuit breaker trip when the breaker did not trip.

- Initial Investigation: Confirmed this occurred in the absence of an unusual current waveform. Consultation with factory confirmed that the signal was indeed a false instrumentation trigger signal and not a missed trip.

- Corrective Action: Undetermined. Hendry will investigate this at a later date.

- Work Around Effected: Instrumentation operator would actively monitor the alarm during power transfer, reset if activated, confirm that no circuit breaker had tripped, and note conditions at time of trigger signal. Continue flight test.

5.5.2 Discrepancy 2.

- Problem Reported: Ceiling light 10-A AFCB would occasionally trip during light turn on and rapid switch cycling.

- Action Taken: Discrepancy confirmed. Nonuniform, nonrepetitive high-current waveform observed. Note that rapid switch cycling is not a standard procedure.

- Corrective Action: Undetermined. Hendry to analyze waveforms and determine corrective algorithm changes at a later date.

- Work Around Effected: Continue with flight test noting conditions when trip occurs.

5.5.3 Discrepancy 3.

- Problem Reported: Pitot heat 5-A AFCB tripped approximately 30 minutes into flight.

- Action Taken: In accordance with the test plan, the circuit was put into BYPASS for the remainder of the current flight. After the flight, the AFCB trip event was discussed with the flight engineer. It was agreed that the trip was an anomaly and that the flight test could safely be continued with the AFCB in the circuit. No further trips of this circuit breaker occurred.

- Corrective Action: Undetermined.

5.5.4 Discrepancy 4.

- Problem Reported: Window heat 5-A circuit breaker tripped when the mechanic was conducting aircraft preflight and bringing the APU on-line. The mechanic was unable to reset the breaker until power was removed from the breaker by placing the S1 switch in STANDBY. No instrumentation recording was available because of being in the initial stages of preflight.

- Action Taken: In accordance with the test plan, the AFCB trip event was discussed with the flight engineer. It was agreed that the trip was an anomaly and that the flight test could safely be continued with the AFCB in the circuit. No further trips of this circuit breaker occurred.

- Corrective Action: Undetermined.

5.5.5 Discrepancy 5.

- Problem Reported: Landing light 7.5-A AFCB tripped during landing light turn-on. The problem occurred as the throttles were being advanced at the start of taxi onto runway.

- Action Taken: After the aircraft was safely in flight, the trip was discussed with the flight engineer. There was agreement that this trip occurred under conditions similar to those experienced during debug flights at the beginning of the program, and the AFCB could be reset without impacting flight safety.

- Corrective Action: Undetermined.

5.6 HENDRY TROUBLESHOOTING PROCEDURES.

5.6.1 Arc-Fault Troubleshooting Background.

Although AFCBs can detect arcing on the circuit in which it is installed, it cannot determine the location of the arc along the circuit. Furthermore, means for easily troubleshooting an arc fault after an AFCB trip are under development but not currently available. This plan was developed to establish a procedure for troubleshooting AFCB trips, should they occur.

An understanding of current methods of troubleshooting thermal trips will clarify the additional measures needed to troubleshoot an AFCB trip, and specifically, the procedures that will be followed during the FAA AFCB flight test program.

Troubleshooting circuit breakers is an iterative process. Generally, after a thermal circuit breaker trip, troubleshooting begins by evaluating the load(s) powered by the circuit. The load is either tested for correct operation or is removed and replaced if its correct operation cannot be directly determined. The circuit is powered, and if no additional trips are noted, the corrective action is considered complete.

If additional trips of the same circuit occur, there are several options for corrective action. The load may still be suspected, but the problem may not be reproducible on the ground. The circuit breaker itself may be suspect and replaced (tripping of thermal circuit breakers under normal conditions or failure of a circuit breaker to stay closed when depressed, are two common circuit breaker failure modes). Usually, the last item to be checked is the circuit wiring, mainly because of the inherent difficulties in testing and inspecting the wiring.

AFCBs add another dimension of complexity to the troubleshooting problem. AFCBs have two trip modes, thermal (current overload) and arc fault. There are unique procedures for troubleshooting each mode, and unfortunately, if one procedure fails to identify the problem, it

may be necessary to complete the other procedure to be certain that the problem has been resolved. Future AFCBs will have the ability to indicate if the trip mode was thermal- or arc fault-related. The prototypes flown in this test program will not have this feature. However, the data recording instrumentation will be triggered by the AFCBs' arc-fault detection circuit, and therefore, it will be known with certainty if the trip mode was thermal versus arc fault.

If the trip mode was arc fault-related, the question remains was the arc trip a real arc or was it a nuisance trip? The instrumentation being used in these flights will record the current waveforms immediately before and after the AFCB indicates that an arc is present and a trip is initiated. This data will be analyzed by Hendry Aerospace to determine if it appears to be a real arc or a nuisance trip. If it is certain that the trip was nuisance related, then the breaker will be reset and flights testing may resume. If a nuisance trip is not certain, then further diagnostics will be required.

Provisions have been made to baseline the condition of the wiring on the eight circuits that will be used in the tests with TDR. During ground testing of the AFCB test system, each AFCB equipped circuit will be characterized with TDR. This data will form a baseline measurement against which future measurements will be compared. Changes in the measurement indicate possible locations at which the arcing may have occurred.

At this point, it is unclear if TDR is sensitive enough to detect the damage incurred by a wire during an arcing condition. If the TDR fails to identify the location of the fault, visual inspection of the circuit must be performed to determine the source of the fault.

5.6.2 Detailed Troubleshooting Procedures.

All troubleshooting shall be performed by qualified FAA personnel under the direction of the Electrical Systems Designated Engineering Representative, ACT-370.

Upon an AFCB arc-fault trip, the Odyssey data recording system will record the current and voltage waveforms from the eight circuits equipped with AFCBs. A thermal trip of the AFCB or the aircraft circuit breaker will not cause the Odyssey to trigger on and record this data. Therefore, it will be known immediately if the trip was caused by an arc fault. The Hendry Trouble Shooting Procedures are in appendix I.

5.6.3 Detailed Process Flow Chart.

Figure 16 shows the detailed process flow chart of the Hendry AFCB.

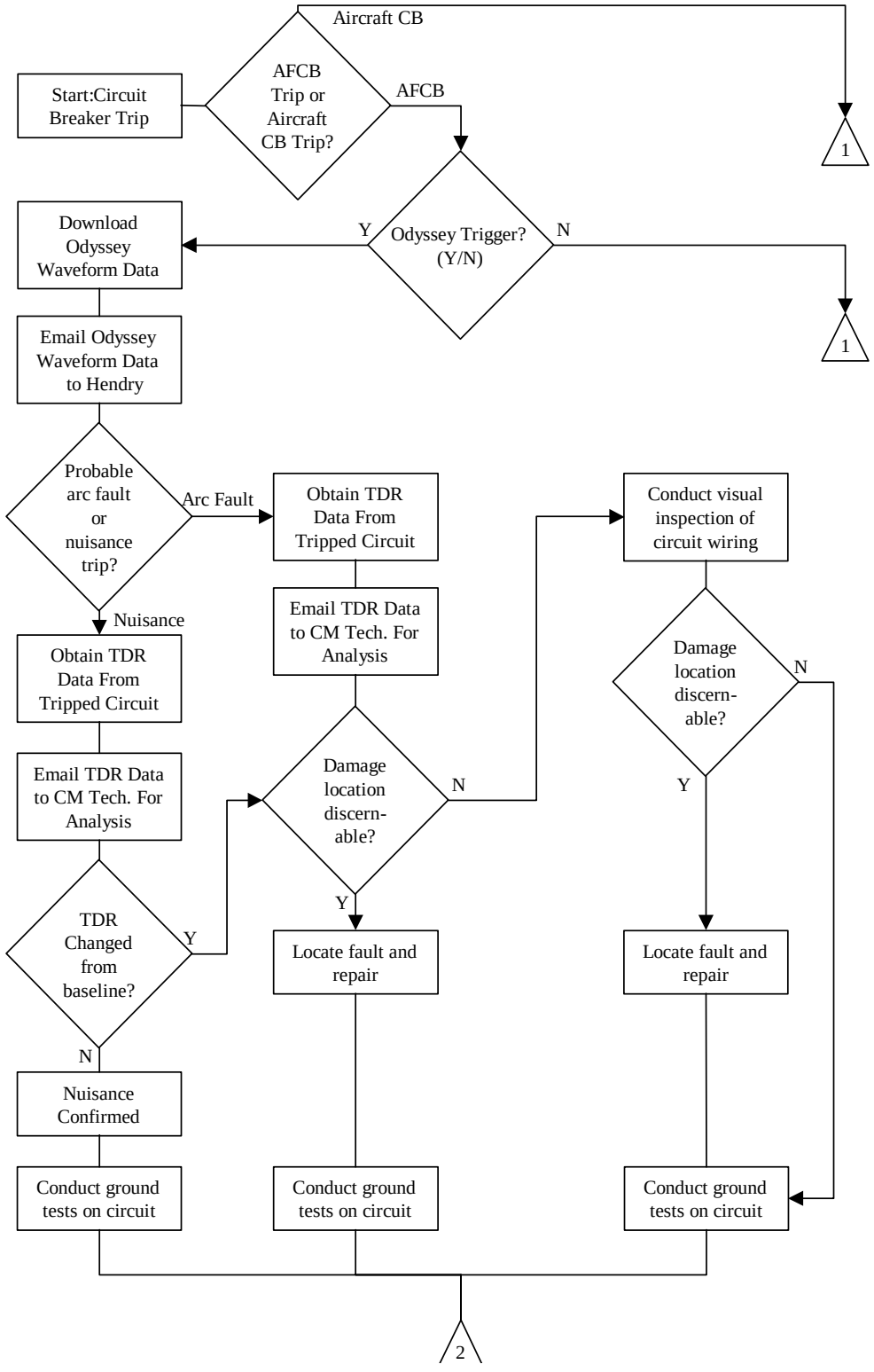


FIGURE 16. HENDRY DETAILED PROCESS FLOW CHART

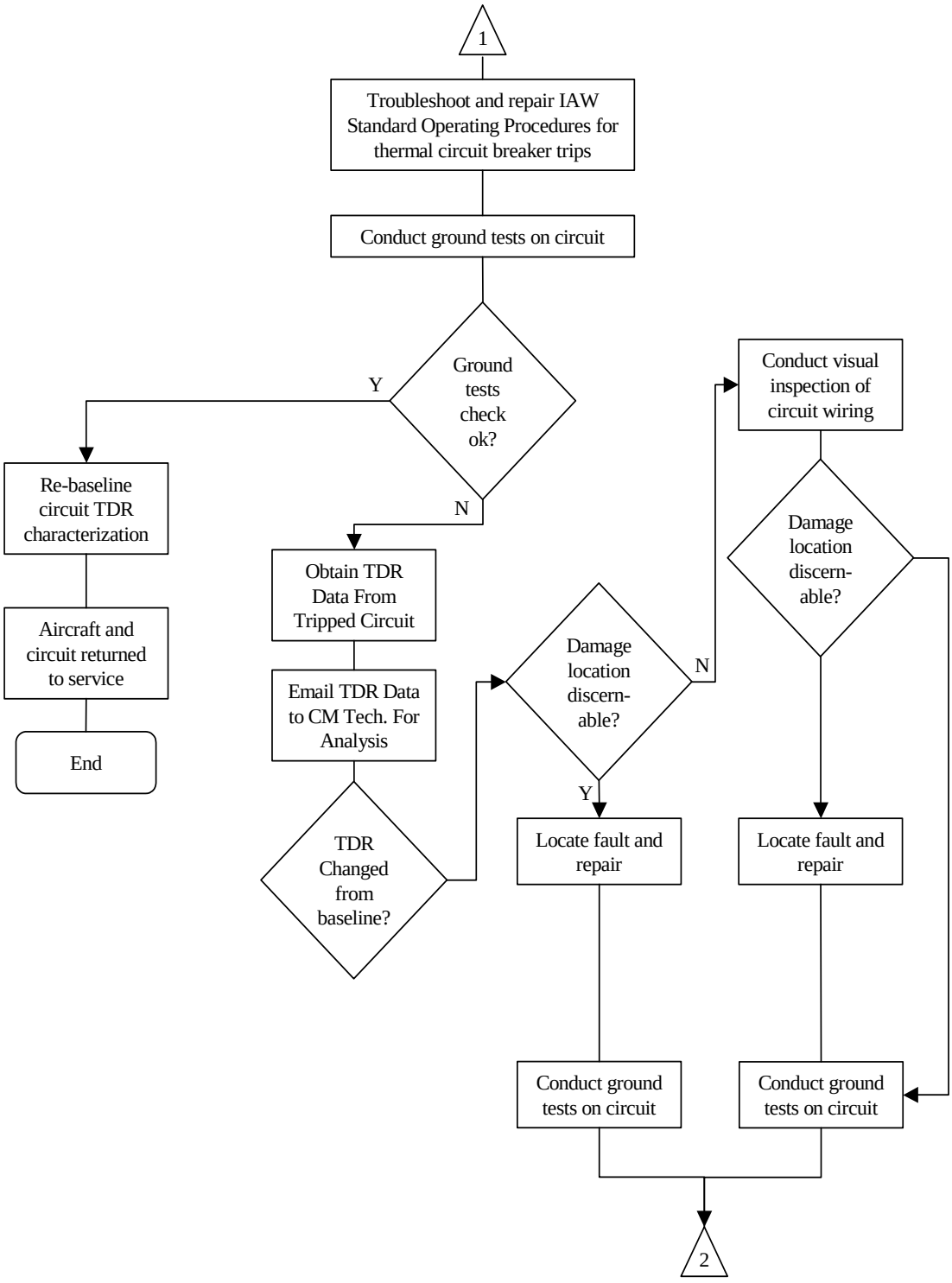


FIGURE 16. HENDRY DETAILED PROCESS FLOW CHART (Continued)

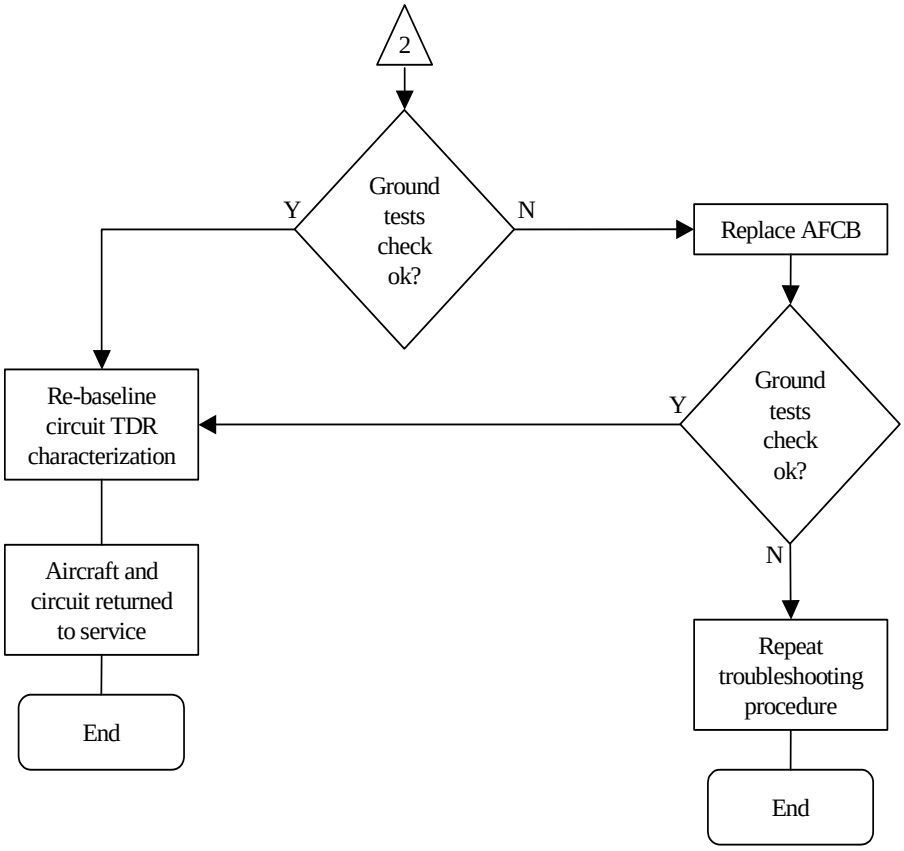


FIGURE 16. HENDRY DETAILED PROCESS FLOW CHART (Continued)

5.7 SUMMARY OF TEST RESULTS.

5.7.1 Eaton Summary.

Although the desired target of 50 flight test hours was not reached, the goal of at least 25 hours was exceeded. The Eaton arc-fault circuit breaker (AFCB) performance was excellent. No nuisance trips were encountered. The anomalies encountered were related to one of the prototype assembly processes. The process associated with brazing the bimetallic element to the AFCB terminal was modified, eliminating the problem. U.S. Navy flight-testing, which lagged the Federal Aviation Administration (FAA) testing by several weeks, provided verification that corrective action was successful.

The tests provided convincing evidence that the Eaton AFCBs were highly resistant to nuisance tripping when exposed to a diverse set of load conditions and electrical transients. The large number and variety of arc-fault tests conducted by Eaton, the U.S. Navy, and the FAA previously validated the sensitivity of the Eaton AFCBs to arc detection. The Eaton design appears to have successfully balanced arc-fault sensitivity and resistance to nuisance trips. This balance is essential for the successful implementation of arc-fault technology into aircraft electrical

distribution systems. In addition, the breakers tested were built to an MS14105 package size that was much smaller than the MS24571 size specified in the contract. This ensures that the breaker will be widely compatible for simple retrofit into the majority of transport aircraft circuit breaker installations.

5.7.2 Hendry Summary.

There were 88 hours of flight-testing, well in excess of the desired 50-hour target. The Hendry AFCB performance was acceptable. Nuisance trips were encountered only during repeatable power transfer and equipment turn-on transient conditions. These anomalies could easily be worked around during the flight test program. Because of the pace of the program and limited aircraft availability, it was not possible to retest with AFCBs containing revised algorithm implementation.

The tests showed that the Hendry AFCBs were highly resistant to nuisance tripping when exposed to a diverse set of load conditions and electrical transients. However, the fact that tripping did occur during normal operational transients indicated that the algorithms used to effect an arc-fault trip and their implementation are not yet mature. The breakers tested were built to a package size that was smaller than the MS24571 size specified in the contract. From this perspective, the breakers will be compatible for simple retrofit into the majority of transport aircraft circuit breaker installations.

APPENDIX A—FLIGHT TEST CERTIFICATION PLAN

Certification Plan

For

Eaton Aerospace Controls
400Hz/120V Arc Fault Circuit Breakers (AFCB)

On

FAA Technical Center
Boeing 727-25C Aircraft
N40

June 2001

FAA William J. Hughes Technical Center
Engineering and Modification Section, ACT-370
Maintenance, Inspection, and Repair Section, AAR-433

Prepared by: R.A. Pappas
J. Beres

Approved by: Armando Gaetano
Manager, Engineering & Modifications Section

1. Introduction

The Federal Aviation Administration (FAA), William J. Hughes Technical Center R&D Flight Program is performing a modification to their Boeing 727-25C aircraft. This temporary modification involves the installation of eight arc fault circuit breaker (AFCB) prototypes manufactured by Eaton Aerospace Controls. The AFCB's are to be installed for a six-month evaluation period in support of AFCB research and development.

The AFCB's will be installed in a pre-furnished Arc Fault Test Unit that will enclose all the AFCB's and required instrumentation. The AFCB's will not be mounted in the aircraft circuit breaker panels. It is important to note that the AFCB's will be connected in series with the load side of the existing thermal circuit breakers. In other words, current circuit protection aboard the aircraft will not be compromised in any way by this installation.

The electrical, system, and mechanical integration of this installation will be accomplished at Atlantic City International Airport (ACIAP) using FAA technical and engineering personnel. The engineering personnel have been granted authority to approve "electrical systems" and "structures" data via FAA Form 8110-3, by the New York Aircraft Certification Office (NYACO). The engineering of this installation has been completed and the engineers are currently compiling reports to show compliance with applicable Federal Aviation Regulations (FAR). All data will be submitted to the NYACO with sufficient time for review, prior to flight-testing.

When the installation of the system is completed, avionics inspectors from the FAA Technical Center Repair Station (#MK1R336K) will perform a "conformity inspection" to determine that the aircraft complies with the approved electrical drawings. Concurrently, ground testing will be completed in accordance with the procedures specified in the Ground Checkout Procedures report.

All data for this installation will be approved via FAA Form 8110-3. Upon completion of this modification and appropriate ground checkout procedures, the FAA Technical Center's Certified Repair Station will return the aircraft to service via FAA Form 337. After being returned to service, the aircraft must undergo a Flight Check of the system. The Flight Check shall be performed in accordance with Flight Checkout Procedures report. This evaluation should result in approval of the Airplane Flight Manual Supplement by the New York Aircraft Certification Office (NYACO).

2. Background

The integration of arc fault detection into circuit breakers represents a revolutionary change in circuit protection; which has changed little in the last thirty to forty years. There is abundant evidence of arc faults in all types of aircraft. Laboratory data clearly demonstrates that the current generated during an arcing fault can be very high, yet quite intermittent. The bimetallic elements in thermal breakers do not react quickly enough, if at all, to this ticking arc fault condition. If left unchecked, the arcing condition can develop into an arc tracking condition, potentially destroying a major portion of, or an entire wire bundle. Arcing can also result in many other serious safety hazards.

In 1999, the FAA and the Navy established a joint R&D project to develop aircraft AFCB's. The goal of this effort is to develop a circuit breaker that integrates arc fault protection together with existing thermal protection into a form, fit, and functional replacement of existing thermal circuit breakers. In laboratory testing, the AFCB prototypes have been very effective in the detection of arcing faults.

In contrast to thermal breakers, which are passive in nature, AFCB's actively monitor the circuits on which they are installed. Due to the nature of electrical systems, there are times when a normal condition may 'look' similar to an arc fault. When such a condition trips an arc fault circuit breaker, it is defined as a nuisance trip. AFCB designs minimize the occurrence of nuisance tripping and maximize sensitivity to arc fault detection.

To address nuisance tripping, the FAA, Navy, and the AFCB developers, have conducted extensive tests to characterize the normal operation of electrical loads, and perturbations to electrical systems during normal events such as bus transfers, power on/off, transfer of power sources, etc. Laboratory tests today have provided a high level of confidence that nuisance tripping is being successfully controlled.

The certification request will permit the FAA to temporarily install AFCB's aboard the B727-25C (N40) with the purpose of evaluating the circuit breakers, in-flight, over a six-month period. This will assure that the AFCB's are evaluated against a wide range of actual electrical conditions.

3. System Description

The AFCB installation will consist of the following:

a. Eight (8) - Eaton Aerospace Corporation prototype arc fault circuit breakers of the following ratings: two 5A, three 7.5A, one 10A, and two 15A.
b. One (1) - Arc Fault Test Unit enclosure.
c. Two (2) – Arc Fault Test Unit Interface wire harnesses.
d. One (1) - 16 channel Nicolet Odyssey data recorder (or similar)
e. Eight (8) - AC Voltage probes (100X), Line-to-ground, 115 volt, 1 MHz.
f. Eight (8) - AC Current Transformers (CT), either 100:5 amps or 50:5 amps.

The Arc Fault Test Unit will contain the eight AFCB units, the voltage probes, and the current transformers. The test unit will be mounted in the rear, left side of the flight deck. The test unit will have by-pass switches that will disable the AFCB's if desired. The test unit will be fabricated using standard best practices and in accordance with AC 43.13-1B and contain any possible AFCB failure. Attachment (1) contains a general description of the Arc Fault Test Unit developed by Boeing for AFCB flight-testing. The FAA AFTU will be equivalent to this unit except that it will contain eight AFCB's rather than six.

The AFCB's will be located inside the Arc Fault Test Unit and will be connected in series with the load side of the existing circuit breakers. A wire harness will be provided to connect the instrumentation to the project rack mounted data recorder located in the cabin. Current levels of safety provided by the existing circuit breakers will not be diminished in any way.

4. Certification Requirements

All aspects of this modification will be in accordance with FAR Part 25, Airworthiness Standards: Transport Category Airplanes. The Issue Paper dated 4/6/01, for AFCB Installation provides alternative means of compliance where this equipment installation cannot meet the regulations.

There are no FAA Technical Standard Orders for the equipment being installed during this modification. This modification is being performed to support AFCB research and development, and will be temporary, not to exceed six months.

5. Method of Compliance

Several methods will be used to determine compliance with FAR Part 25 during this modification. While each item in the Preliminary Compliance Checklist, Table 1, will be discussed at length in the appropriate report, the following paragraphs provide samples of the methods that will be used.

a. Analyses

Items such as a determination of the electrical load and factor of safety for equipment mounting trays will be proven by analysis. (Refer to Electrical System Substantiation and Mechanical Structures Substantiation reports.)

b. Test

Equipment checkout procedures will be available to conduct these tests. (Refer to proposed Ground and Flight Evaluation Procedures.)

c. Software Compliance

Not applicable.

d. Design

The installation was designed so the position of each piece of equipment is located in a suitable location. Electrical equipment is installed in compliance with conventional B727 electrical distribution and load shedding practices. (Refer to Electrical System Substantiation and Mechanical Structures Substantiation reports.)

6. Functional Hazard Assessment Summary

The AFCB is designed to the highest levels of safety and is not a risk to the aircraft. A Systems Safety Analysis will be produced in accordance with AC 25.1309-1A.

7. Operational Considerations

The AFCB provides a greater level of electrical circuit protection than the thermal breakers currently installed. However, AFCBs may occasionally be unnecessarily tripped by a normal load start-up or electrical transient. If such a nuisance trip occurs, the circuit will not be reset, and appropriate troubleshooting will take place when the aircraft returns to the FAA Technical Center. At anytime during a flight, each AFCB can be removed from the circuit by simply throwing a toggle switch mounted on the Arc Fault Test Unit.

During this period of installation, the AFCB's will only be installed on non-critical circuits. No arc testing will be performed on the aircraft. This testing is to evaluate nuisance tripping only.

The airplane flight manual and operating procedures shall be appropriately supplemented.

8. Certification Documentation

Compliance with applicable regulations will be documented on FAA Form 8110-3. The aircraft will be returned to service via Form 337. The Flight Manual Supplement will be approved by the NYACO upon successful completion of flight-testing.

9. Schedule

The B727 will be modified in accordance with the following schedule.

13 July 2001	Modification Complete
16 July 2001	Begin ground checkout (Conformity inspection)
20 July 2001	All reports to NYACO
09 July 2001	*Begin experimental flight test program*
27 July 2001	*Complete experimental flight test program*
25 July 2001	NYACO Safety Review Board
27 July 2001	Flight test with NYACO
01 August 2001	Ground checks and inspections complete. Aircraft returned to service.

Changes to the schedule will be promptly reported to the NYACO.

10. Use of Designees

The following FAA Technical Center Employees have authorization to approve data via FAA Form 8110-3. This authorization has been granted by the NYACO.

Armando Gaetano	Structures
Tim Hogan	Structures
John Beres	Electrical Systems

Table 1 - Preliminary
FAR Part 25 Compliance Checklist
FAA Technical Center B-727 (N40)
Arc Fault Circuit Breaker Installation

FAR	Title	Method	Documentation Reference
Part 25 Subpart C - Structure			
25.301	Loads	Limit and ultimate loads	Mechanical Substantiation Report
25.303	Factor of Safety	FOS applied to limit loads.	"
25.305	Strength and Deformation	Components have adequate strength	"
25.307	Proof of Structure	Strength and deformation required by 25.305 met	"
25.561	Emergency Landing Conditions	Applied to equipment on the flight deck	"
Part 25 Subpart D – Design and Construction			
25.601	Design and Construction/General	Installation IAW manufacturer and AC 43.13-1B	Mechanical Substantiation Report
25.603	Materials	2024-T3 Aluminum/MIL-HDBK-5F chart	"
25.605	Fabrication Methods	Installation IAW manufacturer and AC 43.13-1B	"
25.607	Fasteners	None subject to rotation	"
25.609	Protection of Structure	Protected from deterioration, corrosion, etc.	"
25.611	Accessibility Provisions	Means provided to allow inspections	"
25.613	Material Strength Properties and Design Values	IAW MIL-HDBK-5F	"
Part 25 Subpart F - Equipment			
25.1301	Function and Installation	MIL-C-5809-Circuit Breakers, Trip Free, Aircraft; MIL-PRF-83383-CIRCUIT BREAKERS, REMOTE CONTROL, THERMAL, TRIP FREE GENERAL SPECIFICATION FOR; SAE Draft Spec-Arc Fault Circuit Breakers, Trip Free, Aircraft; Manufacturers Environmental Test Data; AFCB Installation Issue Paper.	Signal Compatibility and Electrical Substantiation Report
25.1307	Miscellaneous Equipment	Circuit breakers are installed in series with the load side of existing aircraft breakers.	"
25.1309	Equipment Systems and Installation	Built to environmental specifications for standard (thermal) circuit breakers, MIL-C-5809, and Remote Control Circuit Breakers (RCCB), MIL-PRF-83383 and AFCB Installation Issue Paper.	"
25.1316	System Lighting Protection	Meet lightning testing per DO-160C, Section 22.0	"
25.1351	Electrical Systems and Equipment/General	Accessible means to disconnect electrical power by crew	"

FAR	Title	Method	Documentation Reference
		members	
25.1353	Electrical Equipment and Installations	Using best practices for electrical equipment and installations.	"
25.1357	Circuit Protective Devices	Existing thermal type, re-settable, trip-free circuit breakers in series with AFCB breakers under test. AFCB Installation Issue Paper.	"
25.1363	Electrical System Tests	Components built and tested to meet applicable aircraft environmental conditions.	"
25.1431	Electronic Equipment	Electronic equipment operation is not affected by this installation.	"
Part 25 Subpart G – Operating Limitations and Information			
25.1541	Markings and Placards/General	New equipment/breakers identifiable in manner visible to crew.	Draft Flight Manual Supplement
25.1581	Airplane Flight Manual/General	Draft flight manual supplement.	"
25.1585	Operating Procedures	Draft flight manual supplement.	"

N-40 Arc Fault Circuit Breaker Installation

Report Listing

Document	Report Number	Contents	**Status**
Certification Plan	E01-02	Reference: AC 21-40, § 2-2.b	
System Description	E01-03	Basic description of AFCB system as installed in N-40.	
Mechanical Substantiation Report	E01-04	Structural load analysis of installed AFCB components, applicable drawings, and FAR compliance discussion.	
Signal Compatibility and Electrical Substantiation	E01-05	Signal compatibility, wiring diagrams, and FAR compliance discussion	
System Safety Assessment	E01-06	System Safety Analysis as per AC 25.1309-1A	
Environmental Test Plan	E01-07	Testing IAW DO-160 or equivalent	
Updated Compliance Checklist	E01-08	Applicable FAR's and Method of Compliance	
Ground Checkout Procedures	E01-09		
Flight Checkout Procedures	E01-10		
Flight Test Procedures	E01-11		
AFCB Troubleshooting Procedures	E01-12	Provides instructions for investigating the source of any AFCB trip prior to reenergizing the circuit.	
Flight Manual Supplement	E01-13	Provides relevant information to flight crew on AFCB operation.	

APPENDIX B—EATON FLIGHT TEST PLAN

Flight Test Plan

For

Eaton Aerospace Controls
400Hz/120V Arc Fault Circuit Breakers (AFCB)

On

FAA Technical Center
Boeing 727-25C Aircraft N40

July 2001

FAA William J. Hughes Technical Center
Engineering and Modification Section, ACT-370
Maintenance, Inspection, and Repair Section, AAR-433

Prepared by: R.A. Pappas

Reviewed by: J. Beres

Approved by: Armando Gaetano
Manager, Engineering & Modifications Section

1. Introduction

The Federal Aviation Administration (FAA), William J. Hughes Technical Center R&D Flight Program is performing a minormodification to their Boeing 727-25C aircraft. This temporary modification involves the installation of eight arc fault circuit breaker (AFCB) prototypes manufactured by Eaton Aerospace Controls. The AFCB's are to be installed for a two-week experimental flight test period in support of AFCB research and development.

The AFCB's will be installed in an Arc Fault Circuit Interrupter-Junction Box (AFCI-JB) that will enclose all the AFCB's and required instrumentation. The AFCB's will not be mounted in the aircraft circuit breaker panels. It is important to note that the AFCB's will be connected in series with the load side of the existing thermal circuit breakers. In other words, current circuit protection aboard the aircraft will not be compromised in any way by this installation.

The electrical, system, and mechanical integration of this installation will be accomplished at Atlantic City International Airport (ACIAP) using FAA technical and engineering personnel. The engineering personnel have been granted authority to approve "electrical systems" and "structures" data via FAA Form 8110-3, by the New York Aircraft Certification Office (NYACO). The engineering of this installation has been completed and the engineers are currently compiling reports to show compliance with applicable Federal Aviation Regulations (FAR).

This flight test plan describes the purpose of the test, the objectives of the flight tests, and the flight test profiles to be flown during the test period.

2. Background

The integration of arc fault detection into circuit breakers represents a revolutionary change in circuit protection; which has changed little in the last thirty to forty years. There is abundant evidence of arc faults in all types of aircraft. Laboratory data clearly demonstrates that the current generated during an arcing fault can be very high, yet quite intermittent. The bimetallic elements in thermal breakers do not react quickly enough, if at all, to this ticking arc fault condition. If left unchecked, the arcing condition can develop into an arc tracking condition, potentially destroying a major portion of, or an entire wire bundle. Arcing can also result in many other serious safety hazards.

In 1999, the FAA and the Navy established a joint R&D project to develop aircraft AFCB's. The goal of this effort is to develop a circuit breaker that integrates arc fault protection together with existing thermal protection into a form, fit, and functional replacement of existing thermal circuit breakers. In laboratory testing, the AFCB prototypes have been very effective in the detection of arcing faults.

In contrast to thermal breakers, which are passive in nature, AFCB's actively monitor the circuits on which they are installed. Due to the nature of electrical systems, there are times when a normal condition may 'look' similar to an arc fault. When such a condition trips an arc fault circuit breaker, it is defined as a nuisance trip. AFCB designs minimize the occurrence of nuisance tripping and maximize sensitivity to arc fault detection.

To address nuisance tripping, the FAA, Navy, and the AFCB developers, have conducted extensive tests to characterize the normal operation of electrical loads, and perturbations to electrical systems during normal events such as bus transfers, power on/off, transfer of power sources, etc. Laboratory tests today have provided a high level of confidence that nuisance tripping is being successfully controlled.

AFCB flight-testing is necessary to be certain that nuisance tripping has been controlled in the AFCB design. The purpose of the experimental flight test period is to monitor the performance of the AFCBs and provide this data to the NYACO in support of a one only STC. The STC will permit the FAA to install AFCB's aboard the B727-25C (N40) for the purpose of evaluating the circuit breakers, in-flight, over a six-month period. This will assure that the AFCB's are evaluated against a wide range of actual electrical conditions.

It is important to note that **no arc faults will be created in the aircraft**. The purpose of the flight testing is to evaluate nuisance tripping only. Arcing will not intentionally be created aboard the aircraft in flight or on the ground.

3. Flight Test Goals

The following list describes the goals of the experimental flight test program, listed in order of importance.

- ❑ Complete at least 50 (or more) flight hours but not less than 25 hours. Data generated during these flights is critical to the AFCB research and development program and for obtaining approval of the N-40 one-only STC.
- ❑ Evaluate the operation of the arc fault circuit breakers under standard B727 operational procedures.
- ❑ Evaluate the operation of the AFCB instrumentation and Odyssey data recording system for future unmanned data collection.

4. System Description

The AFCB installation will consist of the following:

a. Eight (8) - Eaton Aerospace Corporation prototype arc fault circuit breakers of the following ratings: two 5A, three 7.5A, one 10A, and two 15A (Mounted in AFCI Junction Box).

b. One (1) – AFCI-JB.

c. Two (2) – AFCI-JB Test Unit wire harnesses, P18 and P6.

d. One (1) - 24 channel Nicolet Odyssey data recorder.

e. One (1) – BNC Breakout Box.

f. One (1) – AFCI Junction Box – BNC Breakout Box Interface Harness.

g. Twenty-four (24) – 36-inch BNC connector cables.

h. One (1) – Trigger Alarm

The AFCI-JB will contain the eight AFCB units. The test unit will be mounted in the rear, left side of the cockpit. The test unit will have by-pass switches that will disable the AFCB's if desired. The test unit will be fabricated using standard best practices and in accordance with AC 43.13-1B and contain any possible AFCB failure.

The electrical connections for the system are shown schematically in FAA Drawing Number 9854415, Arc Fault Circuit Breaker Wiring. The AFCB's mounted within the AFCI-JB will be electrically in series with the load side of the existing circuit breakers. The AFCI-JB wire harnesses, P-18 and P-6, connect the load side of the each aircraft circuit breaker to the line side of the respective AFCB and from the load side of the each AFCB to the feed wire for the respective load.

The BNC Breakout Box and the Odyssey data recorder will be mounted in the cabin of the aircraft. The AFCI-JB/BNC Breakout Box Interface Harness connects the AFCI-JB to the BNC Breakout Box.

The 24 BNC connectors on the BNC Breakout Box are connected to the Odyssey data recorder with 36" BNC coaxial cables.

Detailed installation instructions are provided the AFCB Ground Test Checkout report.

4. Certification Requirements

There are no FAA Technical Standard Orders for the equipment being installed during this modification. Experimental flight test is being performed to collect data necessary to obtain a one only STC to install the AFCB's aboard N40 for an extended evaluation period.

5. Flight Test Profile Requirements

N40 will be operated in conformance with Standard B727 Operations. The purpose of the flight test is to maximize the number of flight hours. Duration and distance of flights will be at the discretion of the pilot in command and within the operating restrictions established by the MIDO.

No excessive cycling of the aircraft is necessary.

As established by the MIDO, flight restrictions shall be removed to the maximum extent possible upon completion of flight hour thresholds established by the MIDO.

If possible, the aircraft will fly to Sarasota, Florida to permit Eaton Aerospace Corporation engineers an opportunity to assess the AFCB installation aboard the aircraft. A flight to Atlanta, Georgia will also be conducted, if possible, to permit Atlanta ACO engineers to observe the installation.

6. Limitations

It is proposed that the first 10 flight hours (Phase 1) be conducted within a 50-mile radius from Atlantic City International Airport. Upon satisfactory completion of this 10-hour period, it is requested that the remainder of the flights be conducted without restrictions (Phase 2).

An ACT-370 Safety Officer will be on all Phase 1 flights.

An AAR-430 engineer (or designee) must be aboard the aircraft during all AFCB flight tests to operate the Odyssey data recorder.

No AFCB equipped circuit shall be operated in-flight after an AFCB trip on the circuit, unless the pilot in command orders the operation of the circuit during an emergency. In this case, the flight engineer shall switch the associated by-pass switch on the AFCI-JB to the bypass position. In addition, after an AFCB trip, the Flight Engineer shall pull the associated circuit breaker on the aircraft circuit breaker panel. Troubleshooting shall be performed in accordance with the AFCB Troubleshooting Procedures.

If there are two or more AFCB trips on a single electrical bus, the flight test shall be terminated and the aircraft will return to base immediately.

Limitations established by the MIDO shall be adhered to.

7. Emergency Procedures

In the event of an emergency (related or unrelated to the AFCB testing), the following procedures will be followed if order by the pilot in command.

The flight engineer shall by-pass all the AFCB's by closing the AFCB by-pass switches on the AFCB-JB located behind the Captains chair.

- ❑ The flight engineer will set each AFCB to the open position.
- ❑ The Odyssey data recorder will be powered off by the engineer operating the system.

If power must be removed from the AFCB-JB the following steps will be completed:

- ❑ The flight engineer will open the eight circuit breakers on the aircraft circuit breaker panels. These breakers will be uniquely identified by a colored button or other tag. The eight circuit breakers and their respective locations are summarized in Table 1 below.

AFCB #	CB Identity	Panel/Location	Rating (Amps)	Bus
1	Left Inboard Landing Lights	P18-4 Lighting	7	115VAC Bus No. 1
2	Navigation Lights	P18-4 Lighting	5	115VAC Bus No. 2
3	Window Lights	P18-3 Lighting and Passenger Accommodations	10	115VAC Transfer Bus
4	Left Ceiling Lights	P18-3 Lighting and Passenger Accommodations	15	115VAC Transfer Bus
5	DME-2	P18-3 Electronic Load Circuit Breaker	3	115VAC Radio Bus No. 2
6	Heater-Pitot-Aux	P6-1 Miscellaneous AC, Anti-Ice & Rain	5	115VAC Bus No. 2
7	First Officers Window 4 & 5	P6-1 Miscellaneous AC, Anti-Ice & Rain	5	115 VAC Bus No. 3
8	Project Power	Project Power Junction Box	10	115VAC Bus No. 2

Table 1

8. Normal Procedures

a. Preflight

- ❑ Review flight plan with flight crew and all passengers.
- ❑ Review emergency procedures with flight crew and all passengers.
- ❑ Review all normal procedures with flight crew and all passengers.
- ❑ Flight engineer set all bypass switches on the AFCI-JB to normal.
- ❑ Apply power to the aircraft (Ground power or APU).
- ❑ Flight engineer open AFCB-1, AFCB-2, AFCB-3, AFCB-4, AFCB-6, and AFCB-7. Close AFCB-5 and AFCB-8.
- ❑ Turn Odyssey data recorder to ON and wait for system to boot up and initialize. Start recording. Note the date, time, and recording number.
- ❑ Flight engineer close AFCB-1, AFCB-2, AFCB-3, AFCB-4, AFCB-6, and AFCB-7, on the AFCI-JB.
- ❑ If on ground power, start APU. Start Odyssey data recording and instruct flight engineer to transfer power from ground power to APU power. Stop data recording as soon as power transfer is complete. Record the date, time, and filename of the recording in the test logbook. Note that the recording was a ground power to APU transfer.
- ❑ If on APU power, start aircraft engines. Start Odyssey data recording and instruct flight engineer to transfer power from APU to engine generators. Stop data recording as soon as power transfer is complete. Record the date, time, and

filename of the recording in the test logbook. Note that the recording was an APU to engine generator power transfer.

- ❑ Start the Odyssey data recording. Data will be recorded at the slow rate, 1kHz. Note the date, time, and filename in the test logbook. Also note the general conditions (weather, etc.) at this time.
- ❑ Proceed to flight phase in accordance with standard B727 start-up procedures.

b. Flight

- ❑ Monitor Odyssey data recording system. The visual and aural trigger alarm mounted adjacent to the Odyssey data recorder will initiate when an AFCB has tripped and the Odyssey data recorder will automatically begin recording at the high sampling rate, 100kHz.
- ❑ If the trigger-alarm sounds, depress the red reset button mounted on the trigger alarm enclosure to silence the trigger and extinguish the trigger alarm lights.
- ❑ Stop the data recording and start a new data recording file.
- ❑ Note the date, time, and the number of the AFCB(s) that caused the trigger. Also note the flight conditions and other information pertinent to the trigger event in the test logbook. Also note the new file name in the logbook with the start time of the recording.

c. Postflight

- ❑ Continue to follow the flight procedures.
- ❑ Prior to engine shutdown, start APU or apply ground power. Switch aircraft power to APU or ground power. Shut engines in accordance with standard B727 operational procedures.
- ❑ Shutdown the Odyssey data recorder.
- ❑ Shutdown aircraft in accordance with standard B727 operational procedures.

End of flight test procedures.

APPENDIX C—EATON GROUND CHECKOUT PROCEDURES

Ground Test Checkout

For

Eaton Aerospace Controls
400Hz/120V Arc Fault Circuit Breakers (AFCB)

On

FAA Technical Center
Boeing 727-25C Aircraft N40

July 2001

FAA William J. Hughes Technical Center
Engineering and Modification Section, ACT-370
Maintenance, Inspection, and Repair Section, AAR-433

Prepared by: R.A. Pappas, AAR-433

Reviewed by: J. Beres, ACT-370

Approved by: Armando Gaetano
Manager, Engineering & Modifications Section, ACT-370

1. Introduction

The Federal Aviation Administration (FAA), William J. Hughes Technical Center (WJHTC) R&D Flight Program is performing a minor modification to their Boeing 727-25C aircraft. This temporary modification involves the installation of eight arc fault circuit breaker (AFCB) prototypes manufactured by Eaton Aerospace Controls. The AFCB's are to be installed for a six-month evaluation period in support of AFCB research and development.

The AFCB's will be installed in a pre-furnished Arc Fault Circuit Interrupter-Junction Box (AFCI-JB) that will enclose all the AFCB's and required instrumentation. The AFCB's will not be mounted in the aircraft circuit breaker panels. It is important to note that the AFCB's will be connected in series with the load side of the existing thermal circuit breakers. In other words, current circuit protection aboard the aircraft will not be compromised in any way by this installation.

The electrical, system, and mechanical integration of this installation will be accomplished at Atlantic City International Airport (ACIAP) using FAA technical and engineering personnel. The engineering personnel have been granted authority to approve "electrical systems" and "structures" data via FAA Form 8110-3, by the New York Aircraft Certification Office (NYACO). The engineering of this installation has been completed and the engineers are currently compiling reports to show compliance with applicable Federal Aviation Regulations (FAR).

This report describes the ground checkout procedures to be conducted prior to commencing flight test. All steps in this procedure shall be successfully completed.

2. Background

The integration of arc fault detection into circuit breakers represents a revolutionary change in circuit protection; which has changed little in the last thirty to forty years. There is abundant evidence of arc faults in all types of aircraft. Laboratory data clearly demonstrates that the current generated during an arcing fault can be very high, yet quite intermittent. The bimetallic elements in thermal breakers do not react quickly enough, if at all, to this ticking arc fault condition. If left unchecked, the arcing condition can develop into an arc tracking condition, potentially destroying a major portion of, or an entire wire bundle. Arcing can also result in many other serious safety hazards.

In 1999, the FAA and the Navy established a joint R&D project to develop aircraft AFCB's. The goal of this effort is to develop a circuit breaker that integrates arc fault protection together with existing thermal protection into a form, fit, and functional replacement of existing thermal circuit breakers. In laboratory testing, the AFCB prototypes have been very effective in the detection of arcing faults.

In contrast to thermal breakers, which are passive in nature, AFCB's actively monitor the circuits on which they are installed. Due to the nature of electrical systems, there are times when a normal condition may 'look' similar to an arc fault. When such a condition trips an arc fault circuit breaker, it is defined as a nuisance trip. AFCB designs minimize the occurrence of nuisance tripping and maximize sensitivity to arc fault detection.

To address nuisance tripping, the FAA, Navy, and the AFCB developers, have conducted extensive tests to characterize the normal operation of electrical loads, and perturbations to electrical systems during normal events such as bus transfers, power on/off, transfer of power sources, etc. Laboratory tests today have provided a high level of confidence that nuisance tripping is being successfully controlled.

The certification request will permit the FAA to temporarily install AFCB's aboard the B727-25C (N40) with the purpose of evaluating the circuit breakers, in-flight, over a six-month period. This will assure that the AFCB's are evaluated against a wide range of actual electrical conditions.

3. System Description

The AFCB installation will consist of the following:

a. Eight (8) - Eaton Aerospace Corporation prototype arc fault circuit breakers of the following ratings: one 2.5 A, three 5A, one 7.5A, one 10A, and two 15A (Mounted in AFCI Junction Box).

b. One (1) – AFCI-JB.

c. Two (2) – AFCI-JB Test Unit wire harnesses, P18 and P6.

d. One (1) - 24 channel, Nicolet Odyssey data recorder.

e. One (1) – BNC Breakout Box.

f. One (1) – AFCI Junction Box – BNC Breakout Box Interface Harness.

❑ Twenty-four (24) – 36-inch BNC connector cables.

g. One (1) – Trigger Alarm

The AFCI Junction Box (AFCI-JB) will contain the eight AFCB units. The test unit will be mounted in the rear, left side of the cockpit. The test unit will have by-pass switches that will disable the AFCB's if desired. The test unit will be fabricated using standard best practices and in accordance with AC 43.13-1B and contain any possible AFCB failure.

The electrical connections for the system are shown schematically in FAA Drawing Number 9854415, Arc Fault Circuit Breaker Wiring. The AFCB's mounted within the AFCI-JB will be electrically in series with the load side of the existing circuit breakers. The AFCI-JB wire harnesses, P-18 and P-6, connect the load side of the each aircraft circuit breaker to the line side of the respective AFCB and from the load side of the each AFCB to the feed wire for the respective load.

The BNC Breakout Box and the Odyssey data recorder will be mounted in the cabin of the aircraft. The AFCI-JB/BNC Breakout Box Interface Harness connects the AFCI-JB to the BNC Breakout Box.

The 24 BNC connectors on the BNC Breakout Box are connected to the Odyssey data recorder with 36" BNC coaxial cables.

Detailed installation instructions are provided in Section 4.

4. Certification Requirements

There are no FAA Technical Standard Orders for the equipment being installed during this modification. Experimental flight test is being performed to collect data necessary to obtain a one only STC to install the AFCB's aboard N40 for an extended evaluation period.

5. Installation of AFCB Test System On N40

The electrical installation shall be completed in accordance with drawing number 9854415 under the guidance of the WJHTC Electrical Systems Designated Engineering Representative (DER), Code ACT-370. The mechanical installation shall be completed under the guidance of the WJHTC Mechanical Systems DER, Code ACT-370.

The following list contains general instructions for completing the installation. The installation shall be completed in accordance with all existing safety requirements and the necessary approvals shall be obtained in advance of starting the installation.

- ❑ The two AFCI-JB Interface wire harnesses, P-18 and P-6, shall be connected to the thermal circuit breakers in accordance with FAA Drawing number 9854415.

  Harness P-18 shall be connected to the:

  - Left Inboard Landing Lights (7.5A)
  - Navigation Lights (5A)
  - Window Lights (10A)
  - Left Ceiling Lights (15A)

  Harness P-6 shall be connected to the:

  - DME-2 (3A)
  - Auxiliary Pitot Heat (5A)
  - First Officers Window (5A)
  - AC Project Power (15A)

- ❑ Mount the AFCI-JB in the flight deck as per the Mechanical Systems DER instructions.
- ❑ Mount the Odyssey and the BNC Breakout Box in the cabin rack per the Mechanical Systems DER instructions.
- ❑ Insure that all mounting is secure.
- ❑ Route the AFCI-JB harnesses and the AFCI-JB/Breakout Box harness. Do not mate the harnesses to the AFCI-JB or the breakout box until electrical tests have been completed. Do not secure the harness until electrical tests have been completed.

6. Ground Checkout Procedures

Part A: Conduct AFCB Electrical Tests

- ❑ Confirm that the P-18 and P-6 harnesses from the aircraft circuit breaker panels to P1 and P2 on the AFCI-JB are disconnected from the AFCI-JB.
- ❑ Prior to connecting the harnesses to the AFCI-JB, perform the following continuity and isolation checks performed in accordance with Table 1.

AFCI-JB Connector Test Points	AFCB-x Position (Open/Closed) (x =1,2,3,4,5,6,7,8)	AFCB By-Pass Switch S-x (Open/Closed) (x = 1,2,3,4,5,6,7,8)	Observed Condition
P1, 1 and 2	AFCB-1, Closed	S-1, Open	Short
P1, 4 and 5	AFCB-2, Closed	S-2, Open	Short
P1, 7 and 8	AFCB-3, Closed	S-3, Open	Short
P1, 10 and 11	AFCB-4, Closed	S-4, Open	Short
P2, 1 and 2	AFCB-5, Closed	S-5, Open	Short
P2, 4 and 5	AFCB-6, Closed	S-6, Open	Short
P2, 7 and 8	AFCB-7, Closed	S-7, Open	Short
P2, 10 and 11	AFCB-8, Closed	S-8, Open	Short
P1, 1 and 2	AFCB-1, Open	S-1, Open	Open
P1, 4 and 5	AFCB-2, Open	S-2, Open	Open
P1, 7 and 8	AFCB-3, Open	S-3, Open	Open
P1, 10 and 11	AFCB-4, Open	S-4, Open	Open
P2, 1 and 2	AFCB-5, Open	S-5, Open	Open
P2, 4 and 5	AFCB-6, Open	S-6, Open	Open
P2, 7 and 8	AFCB-7, Open	S-7, Open	Open
P2, 10 and 11	AFCB-8, Open	S-8, Open	Open
P1, 1 and 2	AFCB-1, Open	S-1, Closed	Short
P1, 4 and 5	AFCB-2, Open	S-2, Closed	Short
P1, 7 and 8	AFCB-3, Open	S-3, Closed	Short
P1, 10 and 11	AFCB-4, Open	S-4, Closed	Short
P2, 1 and 2	AFCB-5, Open	S-5, Closed	Short
P2, 4 and 5	AFCB-6, Open	S-6, Closed	Short
P2, 7 and 8	AFCB-7, Open	S-7, Closed	Short
P2, 10 and 11	AFCB-8, Open	S-8, Closed	Short
AFCB-1, Red & Black Banana Plug Sockets	AFCB-1, Closed	S-1, Open	Short
AFCB-2, Red & Black Banana Plug Sockets	AFCB-2, Closed	S-2, Open	Short
AFCB-3, Red & Black Banana Plug Sockets	AFCB-3, Closed	S-3, Open	Short
AFCB-4, Red & Black Banana Plug Sockets	AFCB-4, Closed	S-4, Open	Short

AFCB-5, Red & Black Banana Plug Sockets	AFCB-5, Closed	S-5, Open	Short
AFCB-6, Red & Black Banana Plug Sockets	AFCB-6, Closed	S-6, Open	Short
AFCB-7, Red & Black Banana Plug Sockets	AFCB-7, Closed	S-7, Open	Short
AFCB-8, Red & Black Banana Plug Sockets	AFCB-8, Closed	S-8, Open	Short
AFCB-1, Red & Black Banana Plug Sockets	AFCB-1, Open	S-1, Open	Open
AFCB-2, Red & Black Banana Plug Sockets	AFCB-2, Open	S-2, Open	Open
AFCB-3, Red & Black Banana Plug Sockets	AFCB-3, Open	S-3, Open	Open
AFCB-4, Red & Black Banana Plug Sockets	AFCB-4, Open	S-4, Open	Open
AFCB-5, Red & Black Banana Plug Sockets	AFCB-5, Open	S-5, Open	Open
AFCB-6, Red & Black Banana Plug Sockets	AFCB-6, Open	S-6, Open	Open
AFCB-7, Red & Black Banana Plug Sockets	AFCB-7, Open	S-7, Open	Open
AFCB-8, Red & Black Banana Plug Sockets	AFCB-8, Open	S-8, Open	Open
AFCB-1, Red & Black Banana Plug Sockets	AFCB-1, Open	S-1, Closed	Short
AFCB-2, Red & Black Banana Plug Sockets	AFCB-2, Open	S-2, Closed	Short
AFCB-3, Red & Black Banana Plug Sockets	AFCB-3, Open	S-3, Closed	Short
AFCB-4, Red & Black Banana Plug Sockets	AFCB-4, Open	S-4, Closed	Short
AFCB-5, Red & Black Banana Plug Sockets	AFCB-5, Open	S-5, Closed	Short
AFCB-6, Red & Black Banana Plug Sockets	AFCB-6, Open	S-6, Closed	Short
AFCB-7, Red & Black Banana Plug Sockets	AFCB-7, Open	S-7, Closed	Short
AFCB-8, Red & Black Banana Plug Sockets	AFCB-8, Open	S-8, Closed	Short

TABLE 1 – AFCI-JB CHECKOUT

- ❑ Open the eight AFCB's in the AFCI-JB.
- ❑ Open S-1 through S-8 on the AFCI-JB.
- ❑ Open the eight aircraft circuit breakers.
- ❑ With aircraft power off, connect harness P-18 to AFCI-JB connector P-1 and harness P-6 to AFCI-JB connector P2.
- ❑ Apply power (ground power or APU) to the aircraft. Close the eight aircraft circuit breakers and verify that the associated load is not energized.
- ❑ Close AFCI-JB S-1 and verify via visual means that the LEFT INBOARD LANDING LIGHTS are operating. Open S-1.
- ❑ Close AFCI-JB S-2 and verify via visual means that the OSCILLATING NAVIGATION LIGHTS are operating. Open S-2.
- ❑ Close AFCI-JB S-3 and verify via visual means that the WINDOW LIGHTS – LEFT SIDE are operating. Open S-3.

- ❑ Close AFCI-JB S-4 and verify via visual means that the PASSENGER CEILING LIGHTS – LEFT SIDE are operating. Open S-4.
- ❑ Close AFCI-JB S-5 and verify via visual means that the DME is operating. Open S-5.
- ❑ Close AFCI-JB S-6 and verify via the Pitot Ammeter that the HEATER-PITOT-AUX is operating. Open S-6.
- ❑ Close AFCI-JB S-8 and verify that the PROJECT POWER is operating. Open S-8.
- ❑ Close AFCB-1 and verify via visual means that the LEFT INBOARD LANDING LIGHTS are operating. Open AFCB-1.
- ❑ Close AFCB-2 and verify via visual means that the OSCILLATING NAVIGATION LIGHTS are operating. Open AFCB-2.
- ❑ Close AFCB-3 and verify via visual means that the WINDOW LIGHTS – LEFT SIDE are operating. Open AFCB-3.
- ❑ Close AFCB-4 and verify via visual means that the PASSENGER CEILING LIGHTS – LEFT SIDE are operating. Open AFCB-4.
- ❑ Close AFCB-5 and verify via visual means that the DME is operating. Open AFCB-5.
- ❑ Close AFCB-6 and verify via the Pitot Ammeter that the HEATER-PITOT-AUX is operating. Open AFCB-6.
- ❑ Close AFCB-8 and verify that PROJECT POWER is operating. Open AFCB-8.
- ❑ Open the eight aircraft circuit breakers.
- ❑ Connect the P-3 connector on the AFCI-JB to P-4 on the BNC Breakout Box with the AFCI-JB/BNC Breakout Box Interface Harness.
- ❑ Using the 36" BNC connector cables, connect the BNC Breakout Box to the Odyssey data recorder in accordance with Table 2. For the eight channels noted in Table 2, install a 50 Ohm in-line terminator between the BNC cable and the Odyssey data recorder.

From BNC Breakout Box Connector BNC-x (x = 1,2,3…..22,23,24)	To Odyssey Data Recorder Channel Number x (x = 1,2,3…..22,23,24)	50-Ohm In-line Terminator Required? (Y/N)	Description
BNC-1	1	N	AFCB–1 Line Volts
BNC-2	2	N	AFCB-1 Load Volts
BNC-3	3	Y	AFCB-1 Current
BNC-4	4	N	AFCB–2 Line Volts
BNC-5	5	N	AFCB-2 Load Volts
BNC-6	6	Y	AFCB-2 Current
BNC-7	7	N	AFCB–3 Line Volts
BNC-8	8	N	AFCB-3 Load Volts
BNC-9	9	Y	AFCB-3 Current

BNC-10	10	N	AFCB–4 Line Volts
BNC-11	11	N	AFCB-4 Load Volts
BNC-12	12	Y	AFCB-4 Current
BNC-13	13	N	AFCB–5 Line Volts
BNC-14	14	N	AFCB-5 Load Volts
BNC-15	15	Y	AFCB-5 Current
BNC-16	16	N	AFCB–6 Line Volts
BNC-17	17	N	AFCB-6 Load Volts
BNC-18	18	Y	AFCB-6 Current
BNC-19	19	N	AFCB–7 Line Volts
BNC-20	20	N	AFCB-7 Load Volts
BNC-21	21	Y	AFCB-7 Current
BNC-22	22	N	AFCB–8 Line Volts
BNC-23	23	N	AFCB-8 Load Volts
BNC-24	24	Y	AFCB-8 Current

Table 2

- ❑ Turn on the Odyssey data recorder. Odyssey data recorder takes several minutes to complete the boot process.
- ❑ Close the eight aircraft circuit breakers. Verify that the voltage and current inputs to the data recorder are reading zero.
- ❑ Close AFCB-1 and verify via visual means that the LEFT INBOARD LANDING LIGHTS are operating. Verify that the voltage and current waveforms are being properly measured on the Odyssey data recorder channels 1, 2, and 3.
- ❑ Close AFCB-2 and verify via visual means that the OSCILLATING NAVIGATION LIGHTS are operating. Verify that the voltage and current waveforms are being properly measured on the Odyssey data recorder channels 4, 5, and 6.
- ❑ Close AFCB-3 and verify via visual means that the WINDOW LIGHTS – LEFT SIDE are operating. Verify that the voltage and current waveforms are being properly measured on the Odyssey data recorder channels 7, 8, and 9.
- ❑ Close AFCB-4 and verify via visual means that the PASSENGER CEILING LIGHTS – LEFT SIDE are operating. Verify that the voltage and current waveforms are being properly measured on the Odyssey data recorder channels 10, 11, and 12.
- ❑ Close AFCB-5 and verify via visual means that the DME is operating. Verify that the voltage and current waveforms are being properly measured on the Odyssey data recorder channels 13, 14, and 15.
- ❑ Close AFCB-6 and verify via the Pitot Ammeter that the HEATER-PITOT-AUX is operating. Verify that the voltage and current waveforms are being properly measured on the Odyssey data recorder channels 16, 17, and 18.
- ❑ Close AFCB-7. Verify that the voltage and current waveforms are being properly measured on the Odyssey data recorder channels 19, 20, and 21.
- ❑ Close AFCB-8 and verify that PROJECT POWER is operating. Verify that the voltage and current waveforms are being properly measured on the Odyssey data recorder channels 22, 23 and 24.

- ❑ Open and close the Left Inboard Landing Lights aircraft circuit breaker five times. Verify that AFCB-1 did not nuisance trip during the five open-close cycles.
- ❑ Open and close the Navigation Lights aircraft circuit breaker five times. Verify that AFCB-2 did not nuisance trip during the five open-close cycles.
- ❑ Open and close the Window Lights aircraft circuit breaker five times. Verify that AFCB-3 did not nuisance trip during the five open-close cycles.
- ❑ Open and close the Left Ceiling Lights aircraft circuit breaker five times. Verify that AFCB-4 did not nuisance trip during the five open-close cycles.
- ❑ Open and close the DME-2 aircraft circuit breaker five times. Verify that AFCB-5 did not nuisance trip during the five open-close cycles.
- ❑ Open and close the Auxiliary Pitot Heat aircraft circuit breaker five times. Verify that AFCB-6 did not nuisance trip during the five open-close cycles.
- ❑ Open and close the First Officers Window aircraft circuit breaker five times. Verify that AFCB-7 did not nuisance trip during the five open-close cycles.
- ❑ Open and close the AC Project Power aircraft circuit breaker five times. Verify that AFCB-8 did not nuisance trip during the five open-close cycles.
- ❑ With the eight aircraft circuit breakers and the eight AFCB's closed switch from ground power to APU power. Verify that no nuisance trips occurred. Switch from APU power to engine power. Verify that no nuisance trips occurred. Reverse this process and verify that no nuisance trips occurred after each step. Repeat this cycle four additional times.
- ❑ With aircraft electrical power on (ground, APU, or engine) and the aircraft circuit breakers closed, begin recording on the Odyssey by pressing the record button. Open AFCB-1. The trigger alarm shall activate. Close AFCB-1 and reset the trigger alarm. Repeat this process for AFCB-2 through AFCB-8.
- ❑ With aircraft electrical power on (ground, APU, or engine) and the aircraft circuit breakers and AFCB's closed, test aircraft systems in accordance with the B727 Standard Start-up checklist. An Odyssey data recording shall be made as each load is tested. For voice communication, conduct transmission checks on each radio. No AFCB's shall nuisance trip during these tests. Confirm that the AFCB's and instrumentation do not interfere with the operation of system.

Part B: Conduct Time Domain Reflectometry Baseline Tests

The eight AFCB test circuits will be characterized using a Time Domain Reflectometry (TDR) technique. The purpose of this test is to baseline the existing condition of each circuit to be used as a reference benchmark. If an AFCB should trip during flight test, a new TDR measurement of the effected circuit will be conducted and compared to the original benchmark. This will assist in determining the presence and location of the fault.

The TDR testing will be conducted by CM Technologies under the supervision of John Beres.

TDR Tools and Equipment:

The tools and equipment listed below shall be supplied by CM Technologies.

- Electrical Characterization and Diagnostics ($ECAD_{TM}$) System 1100. The $ECAD_{TM}$ system injects a pulse of 1V amplitude, and 400μsec pulse width. In the worst case, the maximum energy of the pulse is 8μJ. The pulse applied in the Excited Dielectric Test (EDT), described below, is even lower. The pulse amplitude is only 200 mV and the pulse width is narrower than the 400μsec pulse used in the standard TDR test.
- Agilent 86100A Oscilloscope Mainframe with 54754A Time Domain Reflectometer Plug-in Module.
- Tabor 8020 Function Generator.
- Coupling network, test lead cables, and clips.

TDR PRECAUTIONS

The $ECAD_{TM}$ System 1100 is designed to test de-energized wires. Computer logic first checks the circuit for AC and DC voltage and will not permit an automatic test if a significant voltage level is found (greater than 5 VDC or VAC). Attempting to test energized wiring may damage the ECAD instrumentation and/or represent a safety hazard to test personnel.

TDR TEST SUPERVISION

- ❑ The WJHTC Electrical Systems DER, Code ACT-370 is responsible for managing the arc fault circuit breaker installation and testing aboard N40. The CM Technologies field engineer shall discuss the test plan with the Electrical Systems DER to ensure compliance with all applicable FAA quality and/or testing procedures.
- ❑ The WJHTC Electrical Systems DER, Code ACT-370 (or designee) shall be responsible for opening any panels to gain access to breakers, opening breakers to de-energize circuits, and restoring the circuits to an operational (pre-test) condition.

TDR PROCEDURE

ECAD$_{TM}$ System 1100 Equipment Setup:

- ❑ Locate the ECAD$_{TM}$ System 1100 near the circuits to be tested. Ideally, the equipment will be located within 10 to 25 feet from the test location.
- ❑ Provide the equipment with a source of 120 VAC, 60 Hz power.
- ❑ Connect power, signal, and test leads to the equipment as required.
- ❑ Turn on the ECAD$_{TM}$ System 1100 and start the data acquisition software.
- ❑ Load the AFCB database files.
- ❑ Execute the system self-test. The self-test checks the proper operation of each instrument card and measures the electrical properties associated with the test lead.

ECAD$_{TM}$ Testing:

- ❑ Select the device/circuit to be tested from the ECAD AFCB database.
- ❑ Verify the circuit to be tested matches the circuit descriptive data (CDD) displayed in the ECAD$_{TM}$ software. Also, verify the circuit to be tested is de-energized.
- ❑ Connect the ECAD$_{TM}$ test clips to the circuit as indicated in the HIGH TEST PT and LOW TEST PT fields of the CDD screen.
- ❑ Using a digital multi-meter, measure resistance from the conductor to aircraft ground. If resistance is less than 500kΩ stop the test and find troubleshoot the circuit wiring. If greater than 500kΩ, proceed to next step.
- ❑ The Insulation Resistance (IR) TEST VOLTS field of the CDD screen indicates the MAXIMUM IR test voltage that is allowed. The maximum applied voltage will be 50VDC. Testing at voltages greater than this value could damage circuit components. A value of zero (0) volts in this field indicates that an IR test is not to be performed for this configuration.
- ❑ Initiate a TEST of the selected configuration.
- ❑ Review the measurement data as required.
- ❑ Repeat ECAD Testing steps until all of the eight circuits have been characterized.

Excited Dielectric Test (EDT) Equipment Setup:

- ❑ Locate the EDT test equipment near the circuits to be tested. Ideally, the equipment will be located within 10 to 25 feet from the test location.
- ❑ Provide the equipment with a source of 120 VAC, 60 Hz power.
- ❑ Connect power, signal, and test leads to the equipment as required.
- ❑ Turn on the Agilent 86100A.

EDT Testing:

- ❑ Connect the alligator test clips to the same test locations that were used during the ECAD testing.
- ❑ Acquire three (3) TDR signatures using three (3) forcing function frequencies. The three frequencies will be determined from the insulation materials used in the circuit under test.
- ❑ Waveforms will be named and saved for storage in the Agilent 86100A.
- ❑ Review the TDR waveform as required.
- ❑ Repeat EDT Testing steps until all of the test configurations have been completed.

Circuit Restoration:

- ❑ Disconnect all test clips.
- ❑ Restore the circuit to normal as directed by the Electrical Systems DER.
- ❑ Perform functional test on the restored circuit, if needed.

Successful completion of these steps will confirm that the installation is functioning properly.

End of Ground Checkout Procedure.

APPENDIX D—EATON FLIGHT TEST RECORDS

EATON FLIGHT TEST HOURS

Flight	Date	From	To	In Service Time	Block Time	Cumulative In Service	Cumulative Block	Circuit Breaker Hours Block Time	Circuit Breaker Hours Cumulative Block
1	9/10/01	KACY	KACY	0.8	1.2	0.8	1.2	9.6	9.6
2	9/17/01	KACY	KACY	1.9	2.2	2.7	3.4	17.6	27.2
3	9/17/01	KACY	KACY	1.6	1.8	4.3	5.2	14.4	41.6
4	9/18/01	KACY	KACY	1.7	2.0	6.0	7.2	16.0	57.6
5	9/18/01	KACY	KACY	1.7	2.0	7.7	9.2	16.0	73.6
6	9/19/01	KACY	KACY	2.4	2.7	10.1	11.9	21.6	95.2
7	9/26/01	KACY	KACY	1.7	1.9	11.8	13.8	13.3	108.5
8	9/27/01	KACY	KACY	1.7	2.0	13.5	15.8	14.0	122.5
9	9/27/01	KACY	KACY	1.2	1.5	14.7	17.3	10.5	133.0
10	10/1/01	KACY	KPBI	2.3	2.6	17.0	19.9	18.2	151.2
11	10/1/01	KPBI	KACY	2.4	2.4	19.4	22.3	16.8	168.0
12	10/2/01	KACY	KATL	1.3	1.9	20.7	24.2	13.3	181.3
13	10/2/01	KATL	KACY	1.6	2.0	22.3	26.2	14.0	195.3
14	10/3/01	KACY	KSRQ	2.1	2.3	24.4	28.5	16.1	211.4
15	10/3/01	KSRQ	KACY	2.0	2.4	26.4	30.9	16.8	228.2

FAA AIRCRAFT REQUEST AND USE RECORD

(Use of FAA aircraft must be in compliance with Order 4040.9 series)

AIRCRAFT REQUEST

1. Source of Aircraft	2. Type Aircraft Desired	2.a Type of Flight	3. Date Required
☒ FAA ☐ Rental ☐ Out of Agency Crew Data Only	B727	☒ FAR 91 ☐ FAR 135 ☐ FAR 125 ☐ Public	9/10/01

4. Justification. *(Explain why Agency/Rental Aircraft is being used. Show proposed itinerary, names/number of passengers and crew, estimated flight hours, and rental cost.)*

DATA COLLECTION AND SYSTEM
EVALUATION IN ACCORDANCE WITH
APPROVED FLIGHT TEST PLAN AND
APPROVED WEEKLY FLIGHT SCHEDULE

Approval Required Before Flight	Signature	Printed Name	Rtg Symbol	Date
5. Requested By:				
6. Approved By:				
6a. Chief or Regional Counsel Approval: *(when required)*				

7. Type Aircraft Used	8. Acft. Code or Rental Category	9. Registration (N) Number	10. Activity	11. User Organization	12. Reimbursement Account
B727	33	N40	T	RDFP	T-170848

13. Purpose of Flight *(AMIS code)*

- ☐ 01. Evaluation
- ☐ 02. Currency
- ☐ 03. Transportation
- ☐ 04. Check Flight
- ☐ 05. Logistics
- ☒ 06. R&D
- ☐ 07. Formal Training
- ☐ 08. Proficiency Q&S
- ☐ 09. Reimbursable
- ☐ 10. Test & Ferry
- ☐ 11. FS Itinerary
- ☐ 12. Accident Investigation
- ☐ 13. Certification Testing
- ☐ 14. Military
- ☐ 15. Observation Flight
- ☐ 16. Other

14. Itinerary

Date	From	To	Block Out	Time in Service Takeoff	Time in Service Landing	Block in	Time in Svc.	Block to Block
a.	b.	c.	d.	e.	f.	g.	h.	i.
9/10/01	KACY	KACY	0915	4885.4	4886.0	1010	0.6	0.9
9/10/01	KACY	KACY	1115	4886.0	4886.8	1225	0.8	1.2

j. Total Time in Service *(Takeoff to landing)* ----------⇒ 1.4

k. Total Flight Time *(Block to Block)* ----------⇒ 2.1

15. Passengers

Full Name of Passenger(s) *(Continue on reverse or attach list)*	RTG Symbol or Agency	From	To
a. List or attach emergency contacts.	b.	c.	d.

⇐ - 15e. Total No. of Passengers

16. Crew Data — Flight Time *(Enter Flight Times in Hours and 1/10)*

a. Crew Identification Name	a1. Crew #	b. PIC HRS	b. PIC 1/10	c. SIC HRS	c. SIC 1/10	d. Pilot HRS	d. Pilot 1/10	e. IP HRS	e. IP 1/10	f. FE HRS	f. FE 1/10	g. Other HRS	g. Other 1/10	h. Hood HRS	h. Hood 1/10	i. Wthr. HRS	i. Wthr. 1/10	j. Night HRS	j. Night 1/10	k. Takeoffs D	k. Takeoffs N	l. Lndgs. D	l. Lndgs. N	m. Hold	n. Aporchs P	n. Aporchs N
BIEHL	CT-006	1	2	0	9	1	2													3		3				
DEMKO	CT-008	0	9	1	2	0	9													3		3				
GAETANO	CT-023									2	1															

17. Rental Aircraft Data

17a. Method of Payment

- ☐ Contract or BPA rental time
  Contract #_____
- ☐ IMPAC Credit Card
- ☐ SF44
- ☐ 3rd Party Check
- ☐ Purchase Order

PO # _____

17b. Charges

A. Total Rental Time, Hrs. / Tenths _____.____

B. Cost / Hr $_____.____

C. Rental Cost (A x B) = $_____.____

D. Other Cost $_____.____

E. Total Cost $_____.____

17c. Aircraft Rented From *(Name, Address, and Phone)*

18. Fuel

Gallons	Cost	Type:	How Purchased:
2164		( ) AVGAS	( ) C - Commercial ( ) D - Contract
		(X) JET	( ) M - Military ( ) W - Wet

19. OFFICE USE ONLY — Verified By — INITIALS — DATE

20. DATABANK ENTRY — Verified By — INITIALS — DATE

FAA Form 4040-6 (12/97) (NSN 0052-00-865-0003) Supersedes previous edition

AFTER FLIGHT: Return to Approving Office Without Delay

1134
1030

FAA AIRCRAFT REQUEST AND USE RECORD

(Use of FAA aircraft must be in compliance with Order 4040.9 series)

AIRCRAFT REQUEST

1. Source of Aircraft	2. Type Aircraft Desired	2.a Type of Flight	3. Date Required
☒ FAA ☐ Rental ☐ Out of Agency Crew Data Only	B727	☒ FAR 91 ☐ FAR 135 ☐ FAR 125 ☐ Public	9/17/01

4. Justification. *(Explain why Agency/Rental Aircraft is being used. Show proposed itinerary, names/number of passengers and crew, estimated flight hours, and rental cost.)*

DATA COLLECTION AND SYSTEM
EVALUATION IN ACCORDANCE WITH
APPROVED FLIGHT TEST PLAN AND
APPROVED WEEKLY FLIGHT SCHEDULE

Approval Required Before Flight	Signature	Printed Name	Rtg Symbol	*Date*
5. Requested By:				
6. Approved By:				
6a. Chief or Regional Counsel Approval: *(when required)*				

7. Type Aircraft Used	8. Acft. Code or Rental Category	9. Registration (N) Number	10. Activity	11. User Organization	12. Reimbursement Account
B727	33	N40	T	RDFP	T170848

13. Purpose of Flight *(AMIS code)*

☐ 01. Evaluation ☐ 02. Currency ☐ 03. Transportation ☐ 04. Check Flight ☐ 05. Logistics ☒ 06. R&D ☐ 07. Formal Training ☐ 08. Proficiency Q&S ☐ 09. Reimbursable ☐ 10. Test & Ferry ☐ 11. FS Itinerary ☐ 12. Accident Investigation ☐ 13. Certification Testing ☐ 14. Military ☐ 15. Observation Flight ☐ 16. Other

14. Itinerary

Date	From	To	Block Out	Time in Service Takeoff	Time in Service Landing	Block In	Time in Svc.	Block to Block
a.	b.	c.	d.	e.	f.	g.	h.	i.
9/17/01	KACY	KACY	0945	4886.8	4888.7	1155	1.9	2.2
9/17/01	ACY	ACY	1325	4889.7	4890.3	1515	1.0	1.8
j. Total Time in Service *(Takeoff to landing)* ⇒							3.5	
k. Total Flight Time *(Block to Block)* ⇒								4.0

15. Passengers

Full Name of Passenger(s) *(Continue on reverse or attach list)*	RTG Symbol or Agency	From	To
a. List or attach emergency contacts.	b.	c.	
PAPPAS, R	AAR433	ACY	ACY
HIRSCH, F		1	1
⇐ 15e. Total No. of Passengers			

16. Crew Data

Flight Time *(Enter Flight Times in Hours and 1/10)*

a. Crew Identification Name	a1. Crew #	b. PIC HRS	b. PIC 1/10	c. SIC HRS	c. SIC 1/10	d. Pilot HRS	d. Pilot 1/10	e. IP HRS	e. IP 1/10	f. FE HRS	f. FE 1/10	g. Other HRS	g. Other 1/10	h. Hood HRS	h. Hood 1/10	i. Wthr. HRS	i. Wthr. 1/10	j. Night HRS	j. Night 1/10	k. Takeoffs D	k. Takeoffs N	l. Ldngs. D	l. Ldngs. N	m. Hold	n. Approchs P	n. Approchs N
BIEHL	CT-006	2	2			1	8													3		3				
KARL	CT-012	1	8	2	2	1	8													5		5				
GAETANO	CT-023									4	0															
GEYSER	CT010			1	8	0	4													3		3				

17. Rental Aircraft Data

17a. Method of Payment

☐ Contract or BPA rental time
Contract #_____

☐ IMPAC Credit Card

☐ SF44

☐ 3rd Party Check

☐ Purchase Order

PO # _____

17b. Charges

A. Total Rental Time, Hrs. / Tenths _____

B. Cost / Hr $_____

C. Rental Cost (A x B) * $_____

D. Other Cost $_____

E. Total Cost $_____

17c. Aircraft Rented From *(Name, Address, and Phone)*

18. Fuel

Gallons	Cost	Type: ~~AVGAS~~ JET	How Purchased: ( ) C - Commercial ( ) D - Contract ( ) M - Military ( ) W - Wet
5436			

18. OFFICE USE ONLY Verified By

INITIALS _____ DATE _____

20. DATABANK ENTRY Verified By

INITIALS _____ DATE _____

FAA Form 4040-6 (12/97) (NSN 0052-00-865-0003) Supersedes previous edition

AFTER FLIGHT: Return to Approving Office Without Delay

2761
2675
~~5436~~

FAA AIRCRAFT REQUEST AND USE RECORD

(Use of FAA aircraft must be in compliance with Order 4040.9 series)

AIRCRAFT REQUEST

1. Source of Aircraft	2. Type Aircraft Desired	2a. Type of Flight	3. Date Required
☒ FAA ☐ Rental ☐ Out of Agency Crew Data Only	B727	☒ FAR 91 ☐ FAR 135 ☐ FAR 125 ☐ Public	9/18/01

4. Justification. *(Explain why Agency/Rental Aircraft is being used. Show proposed itinerary, names/number of passengers and crew, estimated flight hours, and rental cost.)*

DATA COLLECTION AND SYSTEM EVALUATION IN ACCORDANCE WITH APPROVED FLIGHT TEST PLAN AND APPROVED WEEKLY FLIGHT SCHEDULE

Approval Required Before Flight	Signature	Printed Name	Rtg Symbol	*Date*
5. Requested By:				
6. Approved By:	[signature]			
6a. Chief or Regional Counsel Approval: *(when required)*				

7. Type Aircraft Used	8. Acft. Code or Rental Category	9. Registration (N) Number	10. Activity	11. User Organization	12. Reimbursement Account
B727	33	N40	T	RDFP	T170848

13. Purpose of Flight *(AMIS code)*

☐ 01. Evaluation ☐ 02. Currency ☐ 03. Transportation ☐ 04. Check Flight ☒ 06. R&D ☐ 07. Formal Training ☐ 08. Proficiency Q&S ☐ 09. Reimbursable ☐ 10. Test & Ferry ☐ 11. FS Itinerary ☐ 12. Accident Investigation ☐ 13. Certification Testing ☐ 14. Military ☐ 15. Observation Flight ☐ 16. Other

14. Itinerary

Date	From	To	Block Out	Time in Service Takeoff	Time in Service Landing	Block In	Time in Svc.	Block to Block
a.	b.	c.	d.	e.	f.	g.	h.	i.
9/18/01	KACY	KACY	0935	4890.3	4892.0	1135	1.7	2.0
	KACY	KACY	1315	4892.0	4893.7	1515	1.7	2.0
j. Total Time in Service *(Takeoff to landing)* ⇒							3.4	
k. Total Flight Time *(Block to Block)* ⇒								4.0

15. Passengers

Full Name of Passenger(s) *(Continue on reverse or attach list)*	RTG Symbol or Agency	From	To
a. List or attach emergency contacts.	b.	c.	d.
PAPPAS, R	AAR 433	ACY	ACY
Hirsh, F	"	"	"

⇐ - 15e. Total No. of Passengers

16. Crew Data — **Flight Time** *(Enter Flight Times in Hours and 1/10)*

a. Crew Identification Name	a1. Crew #	b. PIC HRS	b. PIC 1/10	c. SIC HRS	c. SIC 1/10	d. Pilot HRS	d. Pilot 1/10	e. IP HRS	e. IP 1/10	f. FE HRS	f. FE 1/10	g. Other HRS	g. Other 1/10	h. Hood HRS	h. Hood 1/10	i. Wthr. HRS	i. Wthr. 1/10	j. Night HRS	j. Night 1/10	k. Takeoffs D	k. Takeoffs N	l. Lndgs. D	l. Lndgs. N	m. Hold	n. Apprchs P	n. Apprchs N
Geysen, J	CTO10	1	0	1	0	1	0													3		3		2		3
Van Hoy, L	CTO07	1	0	1	0	1	0													3		3		2		3
Bactamo, A	CTO23									4	0															
EHRHART	CTO14	1	7		3	1	7													4		4			1	4
VANHOY, L	CTO07		3	1	7		3													1		1				1

17. Rental Aircraft Data

17a. Method of Payment

☐ Contract or BPA rental time
Contract #_____

☐ IMPAC Credit Card

☐ SF44

☐ 3rd Party Check

☐ Purchase Order

PO # _____

17b. Charges

A. Total Rental Time, Hrs. / Tenths _____

B. Cost / Hr $_____

C. Rental Cost (A x B) = $_____

D. Other Cost $_____

E. Total Cost $_____

17c. Aircraft Rented From *(Name, Address, and Phone)*

18. Fuel

Gallons	Cost	Type:	How Purchased:
2400 + 2400 = 4800		( ) AVGAS ☒ JET	( ) C - Commercial ( ) D - Contract ( ) M - Military ( ) W - Wet

19. OFFICE USE ONLY Verified By — INITIALS / DATE

20. DATABANK ENTRY Verified By — INITIALS / DATE

FAA Form 4040-6 (12/97) (NSN 0052-00-885-0003) Supersedes previous edition

AFTER FLIGHT: Return to Approving Office Without Delay

FAA AIRCRAFT REQUEST AND USE RECORD

(Use of FAA aircraft must be in compliance with Order 4040.9 series)

AIRCRAFT REQUEST

1. Source of Aircraft	2. Type Aircraft Desired	2.a Type of Flight	3. Date Required
☒ FAA ☐ Rental ☐ Out of Agency Crew Data Only	B727	☒ FAR 91 ☐ FAR 135 ☐ FAR 125 ☐ Public	9/19/01

4. Justification. *(Explain why Agency/Rental Aircraft is being used. Show proposed itinerary, names/number of passengers and crew, estimated flight hours, and rental cost.)*

DATA COLLECTION AND SYSTEM EVALUATION IN ACCORDANCE WITH APPROVED FLIGHT TEST PLAN AND APPROVED WEEKLY FLIGHT SCHEDULE

Approval Required Before Flight	Signature	Printed Name	Rtg Symbol	*Date*
5. Requested By:				
6. Approved By:				
6a. Chief or Regional Counsel Approval: *(when required)*				

7. Type Aircraft Used	8. Acft. Code or Rental Category	9. Registration (N) Number	10. Activity	11. User Organization	12. Reimbursement Account
B727	33	N40	T	RDFP	T-170848

13. Purpose of Flight *(AMIS code)*

☐ 01. Evaluation ☐ 02. Currency ☐ 03. Transportation ☐ 04. Check Flight ☐ 05. Logistics ☒ 06. R&D ☐ 07. Formal Training ☐ 08. Proficiency Q&S ☐ 09. Reimbursable ☐ 10. Test & Ferry ☐ 11. FS Itinerary ☐ 12. Accident Investigation ☐ 13. Certification Testing ☐ 14. Military ☐ 15. Observation Flight ☐ 16. Other

14. Itinerary

Date	From	To	Block Out	Time in Service Takeoff	Time in Service Landing	Block in	Time in Svc.	Block to Block
a.	b.	c.	d.	e.	f.	g.	h.	i.
9/19/01	ICAGY	ICAGY	1135	4893.7	4896.1	1415	2.4	2.7
j. Total Time In Service *(Takeoff to landing)* ⇒							2.4	
k. Total Flight Time *(Block to Block)* ⇒								2.7

15. Passengers

Full Name of Passenger(s) *(Continue on reverse or attach list)*	RTG Symbol or Agency	From	To
a. List or attach emergency contacts.	b.	c.	d.
AIRSH, F	AAR433	KAGY	KAGY
⇐ 15e. Total No. of Passengers			

16. Crew Data — **Flight Time** *(Enter Flight Times in Hours and 1/10)*

a. Crew Identification Name	a1. Crew #	b. PIC HRS	b. PIC 1/10	c. SIC HRS	c. SIC 1/10	d. Pilot HRS	d. Pilot 1/10	e. IP HRS	e. IP 1/10	f. FE HRS	f. FE 1/10	g. Other HRS	g. Other 1/10	h. Hood HRS	h. Hood 1/10	i. Wthr. HRS	i. Wthr. 1/10	j. Night HRS	j. Night 1/10	k. Takeoffs D	k. Takeoffs N	l. Lndgs. D	l. Lndgs. N	m. Hold	n. Apprchs P	n. Apprchs N
BIEHL	CT-006			2	7	0	3													3		3				
~~EHRHART~~	~~CT-014~~																									
GAETANO	CT-023									2	7															
GEYSER	CT-010	2	7			2	4													3		3				

17. Rental Aircraft Data

17a. Method of Payment

☐ Contract or BPA rental time
Contract #_____

☐ IMPAC Credit Card

☐ SF44

☐ 3rd Party Check

☐ Purchase Order

PO # _____

17b. Charges

A. Total Rental Time, Hrs. / Tenths _____.____

B. Cost / Hr $_____.____

C. Rental Cost (A x B) = $_____.____

D. Other Cost $_____.____

E. Total Cost $_____.____

17c. Aircraft Rented From *(Name, Address, and Phone)*

18. Fuel

Gallons	Cost	Type:	How Purchased:
3060		( ) AVGAS (X) JET	( ) C - Commercial ( ) D - Contract ( ) M - Military ( ) W - Wet

19. OFFICE USE ONLY Verified By — INITIALS — DATE

20. DATABANK ENTRY Verified By — INITIALS — DATE

FAA Form 4040-6 (12/97) (NSN 0052-00-885-0003) Supersedes previous edition

AFTER FLIGHT: Return to Approving Office Without Delay

FAA AIRCRAFT REQUEST AND USE RECORD

(Use of FAA aircraft must be in compliance with Order 4040.9 series)

AIRCRAFT REQUEST

1. Source of Aircraft	2. Type Aircraft Desired	2.a Type of Flight	3. Date Required
☒ FAA ☐ Rental ☐ Out of Agency Crew Data Only	B 727	☒ FAR 91 ☐ FAR 135 ☐ FAR 125 ☐ Public	9/26/01

4. Justification. *(Explain why Agency/Rental Aircraft is being used. Show proposed itinerary, names/number of passengers and crew, estimated flight hours, and rental cost.)*

DATA COLLECTION AND SYSTEM EVALUATION IN ACCORDANCE WITH APPROVED FLIGHT TEST PLAN AND APPROVED WEEKLY FLIGHT SCHEDULE

Approval Required Before Flight	Signature	Printed Name	Rtg Symbol	*Date*
5. Requested By:				
6. Approved By:				
6a. Chief or Regional Counsel Approval: *(when required)*				

7. Type Aircraft Used	8. Acft. Code or Rental Category	9. Registration (N) Number	10. Activity	11. User Organization	12. Reimbursement Account
B727	33	N40	T	RDFP	T.170848

13. Purpose of Flight *(AMIS code)*

☐ 01. Evaluation ☐ 02. Currency ☐ 03. Transportation ☐ 04. Check Flight ☐ 05. Logistics ☑ 06. R&D ☐ 07. Formal Training ☐ 08. Proficiency Q&S ☐ 09. Reimbursable ☐ 10. Test & Ferry ☐ 11. FS Itinerary ☐ 12. Accident Investigation ☐ 13. Certification Testing ☐ 14. Military ☐ 15. Observation Flight ☐ 16. Other

14. Itinerary

Date	From	To	Block Out	Time in Service Takeoff	Time in Service Landing	Block In	Time in Svc.	Block to Block
a.	b.	c.	d.	e.	f.	g.	h.	i.
9/26/01	KACY	KACY	1345	4896.1	4897.8	1540	1.7	1.9
j. Total Time in Service *(Takeoff to landing)* ⇒							1.7	
k. Total Flight Time *(Block to Block)* ⇒								1.9

15. Passengers

Full Name of Passenger(s) *(Continue on reverse or attach list)*	RTG Symbol or Agency	From	To
a. List or attach emergency contacts.	b.	c.	d.
HIRSCH, F	AFFTC/413	KACY	KACY
			⇐ 15e. Total No. of Passengers

16. Crew Data

Flight Time *(Enter Flight Times in Hours and 1/10)*

a. Crew Identification Name	a1. Crew #	b. PIC HRS	b. PIC 1/10	c. SIC HRS	c. SIC 1/10	d. Pilot HRS	d. Pilot 1/10	e. IP HRS	e. IP 1/10	f. FE HRS	f. FE 1/10	g. Other HRS	g. Other 1/10	h. Hood HRS	h. Hood 1/10	i. Wthr. HRS	i. Wthr. 1/10	j. Night HRS	j. Night 1/10	k. Takeoffs D	k. Takeoffs N	l. Lndgs. D	l. Lndgs. N	m. Hold	n. Apprchs P	n. Apprchs N
BIEHL	CT-006	1	9			1	6													4		4				
KARL	CT-012			1	9	0	3													3		3				
GAETANO	CT-023									1	9															

17. Rental Aircraft Data

17a. Method of Payment

☐ Contract or BPA rental time Contract #_____

☐ IMPAC Credit Card

☐ SF44

☐ 3rd Party Check

☐ Purchase Order

PO # _____

17b. Charges

A. Total Rental Time, Hrs. / Tenths _____.____

B. Cost / Hr $_____.____

C. Rental Cost (A x B) = $_____.____

D. Other Cost $_____.____

E. Total Cost $_____.____

17c. **Aircraft Rented From** *(Name, Address, and Phone)*

18. Fuel

Gallons	Cost	Type:	How Purchased:
2300		( ) AVGAS (X) JET	( ) C - Commercial ( ) D - Contract ( ) M - Military ( ) W - Wet

19. OFFICE USE ONLY Verified By — INITIALS — DATE

20. DATABANK ENTRY Verified By — INITIALS — DATE

FAA Form 4040-6 (12/97) (NSN 0052-00-865-0003) Supersedes previous edition

AFTER FLIGHT: Return to Approving Office Without Delay

FAA AIRCRAFT REQUEST AND USE RECORD

(Use of FAA aircraft must be in compliance with Order 4040.9 series)

AIRCRAFT REQUEST

1. Source of Aircraft	2. Type Aircraft Desired	2a. Type of Flight	3. Date Required
☒ FAA ☐ Rental ☐ Out of Agency Crew Data Only	B-727	☒ FAR 91 ☐ FAR 135 ☐ FAR 125 ☐ Public	27 Sept 01

4. Justification. *(Explain why Agency/Rental Aircraft is being used. Show proposed itinerary, names/number of passengers and crew, estimated flight hours, and rental cost.)*

DATA COLLECTION AND SYSTEM
EVALUATION IN ACCORDANCE WITH
APPROVED FLIGHT TEST PLAN AND
APPROVED WEEKLY FLIGHT SCHEDULE

Approval Required Before Flight	Signature	Printed Name	Rtg Symbol	Date
5. Requested By:				
6. Approved By:				
6a. Chief or Regional Counsel Approval: *(when required)*				

7. Type Aircraft Used	8. Acft. Code or Rental Category	9. Registration (N) Number	10. Activity	11. User Organization	12. Reimbursement Account
B727	33	N40	T	RDFP	T708548

13. Purpose of Flight *(AMIS code)*

☐ 01. Evaluation ☐ 02. Currency ☐ 03. Transportation ☐ 04. Check Flight ☐ 05. Logistics ☒ 06. R&D ☐ 07. Formal Training ☐ 08. Proficiency Q&S ☐ 09. Reimbursable ☐ 10. Test & Ferry ☐ 11. FS Itinerary ☐ 12. Accident Investigation ☐ 13. Certification Testing ☐ 14. Military ☐ 15. Observation Flight ☐ 16. Other

14. Itinerary

Date	From	To	Block Out	Time in Service Takeoff	Time in Service Landing	Block in	Time in Svc.	Block to Block
a.	b.	c.	d.	e.	f.	g.	h.	i.
27Sept01	ACY.	ACY	1015	4897.8	4899.5	1215	1.7	2.0
27Sept01	ACY	ACY	1425	4899.5	4901.7	1555	1.2	1.5
j. Total Time in Service *(Takeoff to landing)* ⇒							2.9	
k. Total Flight Time *(Block to Block)* ⇒								3.5

15. Passengers

Full Name of Passenger(s) *(Continue on reverse or attach list)*	RTG Symbol or Agency	From	To
a. List or attach emergency contacts.	b.	c.	d.
Sep Reverse			
⇐ - 15e. Total No. of Passengers			

16. Crew Data

Flight Time *(Enter Flight Times in Hours and 1/10)*

a. Crew Identification Name	a1. Crew #	b. PIC HRS	b. PIC 1/10	c. SIC HRS	c. SIC 1/10	d. Pilot HRS	d. Pilot 1/10	e. IP HRS	e. IP 1/10	f. FE HRS	f. FE 1/10	g. Other HRS	g. Other 1/10	h. Hood HRS	h. Hood 1/10	i. Wthr. HRS	i. Wthr. 1/10	j. Night HRS	j. Night 1/10	k. Takeoffs D	k. Takeoffs N	l. Lndgs. D	l. Lndgs. N	m. Hold	n. Apprchs P	n. Apprchs N
PIAPC	CT012	2	0	1	5	1	5													1		1		1		1
DAMRO	CT008	1	5	2	0	2	0													2		2		1		1
GAETANO	CT023									3	5															

17. Rental Aircraft Data

17a. Method of Payment

☐ Contract or BPA rental time
Contract #_____
☐ IMPAC Credit Card
☐ SF44
☐ 3rd Party Check
☐ Purchase Order
PO # _____

17b. Charges

A. Total Rental Time, Hrs. / Tenths _____.____
B. Cost / Hr $_____.____
C. Rental Cost (A x B) = $_____.____
D. Other Cost $_____.____
E. Total Cost $_____.____

17c. Aircraft Rented From *(Name, Address, and Phone)*

18. Fuel

Gallons	Cost	Type:	How Purchased:
3750		( ) AVGAS ( ) JET	( ) C - Commercial ( ) D - Contract ( ) M - Military ( ) W - Wet

19. OFFICE USE ONLY Verified By — INITIALS — DATE

20. DATABANK ENTRY Verified By — INITIALS — DATE

FAA Form 4040-8 (12/97) (NSN 0052-00-865-0003) Supersedes previous edition

AFTER FLIGHT: Return to Approving Office Without Delay

FAA AIRCRAFT REQUEST AND USE RECORD

(Use of FAA aircraft must be in compliance with Order 4040.9 series)

AIRCRAFT REQUEST

1. Source of Aircraft	2. Type Aircraft Desired	2.a Type of Flight	3. Date Required
☒ FAA ☐ Rental ☐ Out of Agency Crew Data Only	B727	☒ FAR 91 ☐ FAR 135 ☐ FAR 125 ☐ Public	10/1/01

4. Justification. *(Explain why Agency/Rental Aircraft is being used. Show proposed itinerary, names/number of passengers and crew, estimated flight hours, and rental cost.)*

DATA COLLECTION AND SYSTEM EVALUATION IN ACCORDANCE WITH APPROVED FLIGHT TEST PLAN AND APPROVED WEEKLY FLIGHT SCHEDULE

Approval Required Before Flight	Signature	Printed Name	Rtg Symbol	*Date*
5. Requested By:				
6. Approved By:				
6a. Chief or Regional Counsel Approval: *(when required)*				

7. Type Aircraft Used	8. Acft. Code or Rental Category	9. Registration (N) Number	10. Activity	11. User Organization	12. Reimbursement Account
B727	33	N40	T	RDFP	T-170848

13. Purpose of Flight *(AMIS code)*

☐ 01. Evaluation ☐ 02. Currency ☐ 03. Transportation ☐ 04. Check Flight ☐ 05. Logistics ☒ 06. R&D ☐ 07. Formal Training ☐ 08. Proficiency Q&S ☐ 09. Reimbursable ☐ 10. Test & Ferry ☐ 11. FS Itinerary ☐ 12. Accident Investigation ☐ 13. Certification Testing ☐ 14. Military ☐ 15. Observation Flight ☐ 16. Other

14. Itinerary

Date	From	To	Block Out	Time in Service Takeoff	Time in Service Landing	Block in	Time in Svc.	Block to Block
a.	b.	c.	d.	e.	f.	g.	h.	i.
10/1/01	KACY	KPBI	1000	4900.1	4903.0	1235	2.3	2.6
10/1/01	KPBI	KACY	1535	4903.0	4905.4	1800	2.4	2.4
j. Total Time in Service *(Takeoff to landing)* ⇒							4.7	
k. Total Flight Time *(Block to Block)* ⇒								5.0

15. Passengers

Full Name of Passenger(s) *(Continue on reverse or attach list)*	RTG Symbol or Agency	From	To
a. List or attach emergency contacts.	b.	c.	d.
PASPAS R	AAR-433	KACY	KACY
⇐ 15e. Total No. of Passengers			

16. Crew Data — **Flight Time** *(Enter Flight Times in Hours and 1/10)*

a. Crew Identification	a1.	b. PIC		c. SIC		d. Pilot		e. IP		f. FE		g. Other		h. Hood		i. Wthr.		j. Night		k. Takeoffs		l. Lndgs.		m.	n. Apprchs	
Name	Crew #	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	D	N	D	N	Hold	P	N
BIEHL	CT-006	2	6	2	4	2	6									1	0			1		1				
VANHUY	CT-007	2	4	2	6	2	4									1	0			1		1				
GAETANO	CT-023									5	0															

17. Rental Aircraft Data

17a. Method of Payment

☐ Contract or BPA rental time
Contract #_____

☐ IMPAC Credit Card

☐ SF44

☐ 3rd Party Check

☐ Purchase Order

PO # _____

17b. Charges

A. Total Rental Time, Hrs. / Tenths _____

B. Cost / Hr $_____

C. Rental Cost (A x B) = $_____

D. Other Cost $_____

E. Total Cost $_____

17c. Aircraft Rented From *(Name, Address, and Phone)*

18. Fuel

Gallons	Cost	Type:	How Purchased:
5523		( ) AVGAS (☒) JET	( ) C - Commercial ( ) D - Contract ( ) M - Military ( ) W - Wet

19. OFFICE USE ONLY Verified By — INITIALS — DATE

20. DATABANK ENTRY Verified By — INITIALS — DATE

FAA Form 4040-6 (12/97) (NSN 0052-00-865-0003) Supersedes previous edition

AFTER FLIGHT: Return to Approving Office Without Delay

2836
2687
5523

FAA AIRCRAFT REQUEST AND USE RECORD

(Use of FAA aircraft must be in compliance with Order 4040.9 series)

AIRCRAFT REQUEST

1. Source of Aircraft	2. Type Aircraft Desired	2.a Type of Flight	3. Date Required
☒ FAA ☐ Rental ☐ Out of Agency Crew Data Only	B727	☒ FAR 91 ☐ FAR 135 ☐ FAR 125 ☐ Public	10/2/01

4. Justification. *(Explain why Agency/Rental Aircraft is being used. Show proposed itinerary, names/number of passengers and crew, estimated flight hours, and rental cost.)*

DATA COLLECTION AND SYSTEM EVALUATION IN ACCORDANCE WITH APPROVED FLIGHT TEST PLAN AND APPROVED WEEKLY FLIGHT SCHEDULE

Approval Required Before Flight	Signature	Printed Name	Rtg Symbol	*Date*
5. Requested By:				
6. Approved By:				
6a. Chief or Regional Counsel Approval: *(when required)*				

7. Type Aircraft Used	8. Acft. Code or Rental Category	9. Registration (N) Number	10. Activity	11. User Organization	12. Reimbursement Account
B 727	33	N40	T	RDFP	T-170848

13. Purpose of Flight *(AMIS code)*

☐ 01. Evaluation ☐ 02. Currency ☐ 03. Transportation ☐ 04. Check Flight ☐ 05. Logistics ☒ 06. R&D ☐ 07. Formal Training ☐ 08. Proficiency Q&S ☐ 09. Reimbursable ☐ 10. Test & Ferry ☐ 11. FS Itinerary ☐ 12. Accident Investigation ☐ 13. Certification Testing ☐ 14. Military ☐ 15. Observation Flight ☐ 16. Other

14. Itinerary

Date	From	To	Block Out	Time in Service Takeoff	Time in Service Landing	Block In	Time in Svc.	Block to Block
a.	b.	c.	d.	e.	f.	g.	h.	i.
10/2/01	KACY.	KATL	0835	4905.4	4906.7	1030	1.3	1.9
10/2/01	KATL	KACY	1330	4906.7	4908.3	1530	1.6	2.0
j. Total Time in Service *(Takeoff to landing)* ⇒							2.9	
k. Total Flight Time *(Block to Block)* ⇒								3.9

15. Passengers

Full Name of Passenger(s) *(Continue on reverse or attach list)*	RTG Symbol or Agency	From	To
a. List or attach emergency contacts.	b.	c.	d.
PAPPAS, R	AAR-433	KACY	KACY
BERES, J	ACT-370	—	—
			⇐ 15e. Total No. of Passengers

16. Crew Data — **Flight Time** *(Enter Flight Times in Hours and 1/10)*

a. Crew Identification Name	a1. Crew #	b. PIC HRS	b. PIC 1/10	c. SIC HRS	c. SIC 1/10	d. Pilot HRS	d. Pilot 1/10	e. IP HRS	e. IP 1/10	f. FE HRS	f. FE 1/10	g. Other HRS	g. Other 1/10	h. Hood HRS	h. Hood 1/10	i. Wthr. HRS	i. Wthr. 1/10	j. Night HRS	j. Night 1/10	k. Takeoffs D	k. Takeoffs N	l. Lndgs. D	l. Lndgs. N	m. Hold	n. Apprchs P	n. Apprchs N
BIEHL	CT-006	1	9	2	0	1	9													1		1			1	
KARL	CT-012	2	0	1	9	2	0													1		1				
GAETANO	CT-023									3	9															

17. Rental Aircraft Data

17a. Method of Payment

☐ Contract or BPA rental time
Contract #_____

☐ IMPAC Credit Card

☐ SF44

☐ 3rd Party Check

☐ Purchase Order

PO # _____

17b. Charges

A. Total Rental Time, Hrs. / Tenths _____.____

B. Cost / Hr $_____.____

C. Rental Cost (A x B) = $_____.____

D. Other Cost $_____.____

E. Total Cost $_____.____

17c. Aircraft Rented From *(Name, Address, and Phone)*

18. Fuel

Gallons	Cost	Type:	How Purchased:
4608		( ) AVGAS (X) JET	( ) C - Commercial ( ) D - Contract ( ) M - Military ( ) W - Wet

19. OFFICE USE ONLY Verified By — INITIALS ✓ DATE

20. DATABANK ENTRY Verified By — INITIALS DATE

FAA Form 4040-6 (12/97) (NSN 0052-00-885-0003) Supersedes previous edition

AFTER FLIGHT: Return to Approving Office Without Delay

2358
2250
4608

FAA AIRCRAFT REQUEST AND USE RECORD

(Use of FAA aircraft must be in compliance with Order 4040.9 series)

AIRCRAFT REQUEST

1. Source of Aircraft: [X] FAA [ ] Rental [ ] Out of Agency Crew Data Only
2. Type Aircraft Desired: B-727
2a. Type of Flight: [X] FAR 91 [ ] FAR 125 [ ] FAR 135 [ ] Public
3. Date Required: 10/3/01

4. Justification. *(Explain why Agency/Rental Aircraft is being used. Show proposed itinerary, names/number of passengers and crew, estimated flight hours, and rental cost.)*

DATA COLLECTION AND SYSTEM EVALUATION IN ACCORDANCE WITH APPROVED FLIGHT TEST PLAN AND APPROVED WEEKLY FLIGHT SCHEDULE

Approval Required Before Flight	Signature	Printed Name	Rtg Symbol	Date
5. Requested By:				
6. Approved By:				
6a. Chief or Regional Counsel Approval: *(when required)*				

7. Type Aircraft Used	8. Acft. Code or Rental Category	9. Registration (N) Number	10. Activity	11. User Organization	12. Reimbursement Account
B-727	33	40	T	RDFP	T70848

13. Purpose of Flight *(AMIS code)*

[ ] 01. Evaluation [ ] 02. Currency [ ] 03. Transportation [ ] 04. Check Flight [ ] 05. Logistics [X] 06. R&D [ ] 07. Formal Training [ ] 08. Proficiency Q&S [ ] 09. Reimbursable [ ] 10. Test & Ferry [ ] 11. FS Itinerary [ ] 12. Accident Investigation [ ] 13. Certification Testing [ ] 14. Military [ ] 15. Observation Flight [ ] 16. Other

14. Itinerary

Date	From	To	Block Out	Time in Service Takeoff	Time in Service Landing	Block In	Time in Svc.	Block to Block
a.	b.	c.	d.	e.	f.	g.	h.	i.
10/3/01	ACY	SRQ	0830	4908.3	4910.4	1045	2.1	2.3
	SRQ	ACY	1330	4910.4	4912.4	1555	2.0	2.4
j. Total Time in Service *(Takeoff to landing)* ⇒							4.1	
k. Total Flight Time *(Block to Block)* ⇒								4.7

15. Passengers

Full Name of Passenger(s) *(Continue on reverse or attach list)*	RTG Symbol or Agency	From	To
a. List or attach emergency contacts.	b.	c.	d.
⇐ 15e. Total No. of Passengers			

16. Crew Data — Flight Time *(Enter Flight Times in Hours and 1/10)*

a. Crew Identification Name	a1. Crew #	b. PIC HRS	b. PIC 1/10	c. SIC HRS	c. SIC 1/10	d. Pilot HRS	d. Pilot 1/10	e. IP HRS	e. IP 1/10	f. FE HRS	f. FE 1/10	g. Other HRS	g. Other 1/10	h. Hood HRS	h. Hood 1/10	i. Wthr. HRS	i. Wthr. 1/10	j. Night HRS	j. Night 1/10	k. Takeoffs D	k. Takeoffs N	l. Lndgs. D	l. Lndgs. N	m. Hold	n. Apprchs P	n. Apprchs N
EHMKE, M CT	014	2	3	2	4	2	3													1		1				
VANIN, L CT	007	2	4	2	3	2	4													1		1				
GAETANO, A CT	023									4	7															

17. Rental Aircraft Data

17a. Method of Payment

[ ] Contract or BPA rental time
Contract #_____
[ ] IMPAC Credit Card
[ ] SF44
[ ] 3rd Party Check
[ ] Purchase Order
PO # _____

17b. Charges

A. Total Rental Time, Hrs. / Tenths _____.____
B. Cost / Hr $_____.____
C. Rental Cost (A x B) = $_____.____
D. Other Cost $_____.____
E. Total Cost $_____.____

17c. Aircraft Rented From *(Name, Address, and Phone)*

18. Fuel

Gallons	Cost	Type:	How Purchased:
	450	( ) AVGAS ( ) JET	( ) C - Commercial ( ) D - Contract ( ) M - Military ( ) W - Wet

19. OFFICE USE ONLY Verified By — INITIALS — DATE

20. DATABANK ENTRY Verified By — INITIALS — DATE

FAA Form 4040-6 (12/97) (NSN 0052-00-865-0003) Supersedes previous edition

AFTER FLIGHT: Return to Approving Office Without Delay

APPENDIX E—EATON TROUBLESHOOTING PROCEDURES

Troubleshooting Procedures

For

Eaton Aerospace Controls
400Hz/120V Arc Fault Circuit Breakers (AFCB)

On

FAA Technical Center
Boeing 727-25C Aircraft N40

July 2001

FAA William J. Hughes Technical Center
Engineering and Modification Section, ACT-370
Maintenance, Inspection, and Repair Section, AAR-433

Prepared by: R.A. Pappas, AAR-433

Reviewed by: J. Beres, ACT-370

Approved by: Armando Gaetano
Manager, Engineering & Modifications Section, ACT-370

1. Introduction

The Federal Aviation Administration (FAA), William J. Hughes Technical Center (WJHTC) R&D Flight Program is performing a minormodification to their Boeing 727-25C aircraft. This temporary modification involves the installation of eight arc fault circuit breaker (AFCB) prototypes manufactured by Eaton Aerospace Controls. The AFCB's are to be installed for a six-month evaluation period in support of AFCB research and development.

The AFCB's will be installed in a prefurnished Arc Fault Circuit Interrupter-Junction Box (AFCI-JB) that will enclose all the AFCB's and required instrumentation. The AFCB's will not be mounted in the aircraft circuit breaker panels. It is important to note that the AFCB's will be connected in series with the load side of the existing thermal circuit breakers. In other words, current circuit protection aboard the aircraft will not be compromised in any way by this installation.

The electrical, system, and mechanical integration of this installation will be accomplished at Atlantic City International Airport (ACIAP) using FAA technical and engineering personnel. The engineering personnel have been granted authority to approve "electrical systems" and "structures" data via FAA Form 8110-3, by the New York Aircraft Certification Office (NYACO). The engineering of this installation has been completed and the engineers are currently compiling reports to show compliance with applicable Federal Aviation Regulations (FAR).

This report describes the troubleshooting procedures to be conducted in the event there is an AFCB trip during ground testing or flight testing. All steps in this procedure shall be successfully followed until the source of the AFCB trip has been identified and corrected in accordance with this procedure and to the satisfaction of the WJHTC Electrical Systems DER, Code ACT-370.

2. Background

The integration of arc fault detection into circuit breakers represents a revolutionary change in circuit protection; which has changed little in the last thirty to forty years. There is abundant evidence of arc faults in all types of aircraft. Laboratory data clearly demonstrates that the current generated during an arcing fault can be very high, yet quite intermittent. The bimetallic elements in thermal breakers do not react quickly enough, if at all, to this ticking arc fault condition. If left unchecked, the arcing condition can develop into an arc tracking condition, potentially destroying a major portion of, or an entire wire bundle. Arcing can also result in many other serious safety hazards.

In 1999, the FAA and the Navy established a joint R&D project to develop aircraft AFCB's. The goal of this effort is to develop a circuit breaker that integrates arc fault protection together with existing thermal protection into a form, fit, and functional replacement of existing thermal circuit breakers. In laboratory testing, the AFCB prototypes have been very effective in the detection of arcing faults.

In contrast to thermal breakers, which are passive in nature, AFCB's actively monitor the circuits on which they are installed. Due to the nature of electrical systems, there are times when a normal condition may 'look' similar to an arc fault. When such a condition trips an

arc fault circuit breaker, it is defined as a nuisance trip. AFCB designs minimize the occurrence of nuisance tripping and maximize sensitivity to arc fault detection.

To address nuisance tripping, the FAA, Navy, and the AFCB developers, have conducted extensive tests to characterize the normal operation of electrical loads, and perturbations to electrical systems during normal events such as bus transfers, power on/off, transfer of power sources, etc. Laboratory tests today have provided a high level of confidence that nuisance tripping is being successfully controlled.

The certification request will permit the FAA to temporarily install AFCB's aboard the B727-25C (N40) with the purpose of evaluating the circuit breakers, in-flight, over a six-month period. This will assure that the AFCB's are evaluated against a wide range of actual electrical conditions.

3. System Description

The AFCB installation will consist of the following:

a. Eight (8) - Eaton Aerospace Corporation prototype arc fault circuit breakers of the following ratings: one 2.5 A, three 5A, one 7.5A, one 10A, and two 15A (Mounted in AFCI Junction Box).

b. One (1) – AFCI-JB.

c. Two (2) – AFCI-JB Test Unit wire harnesses, P18 and P6.

d. One (1) - 24 channel, Nicolet Odyssey data recorder.

e. One (1) – BNC Breakout Box.

f. One (1) – AFCI Junction Box – BNC Breakout Box Interface Harness.

g. Twenty-four (24) – 36-inch BNC connector cables.

h. One (1) – Trigger Alarm

The AFCI Junction Box (AFCI-JB) will contain the eight AFCB units. The test unit will be mounted in the rear, left side of the cockpit. The test unit will have by-pass switches that will disable the AFCB's if desired. The test unit will be fabricated using standard best practices and in accordance with AC 43.13-1B and contain any possible AFCB failure.

The electrical connections for the system are shown schematically in FAA Drawing Number 9854415, Arc Fault Circuit Breaker Wiring. The AFCB's mounted within the AFCI-JB will be electrically in series with the load side of the existing circuit breakers. The AFCI-JB wire harnesses, P-18 and P-6, connect the load side of the each aircraft circuit breaker to the line side of the respective AFCB and from the load side of the each AFCB to the feed wire for the respective load.

The BNC Breakout Box and the Odyssey data recorder will be mounted in the cabin of the aircraft. The AFCI-JB/BNC Breakout Box Interface Harness connects the AFCI-JB to the BNC Breakout Box.

The 24 BNC connectors on the BNC Breakout Box are connected to the Odyssey data recorder with 36" BNC coaxial cables.

Detailed installation instructions are provided in Section 4.

4. Certification Requirements

There are no FAA Technical Standard Orders for the equipment being installed during this modification. Experimental flight test is being performed to collect data necessary to obtain a one only STC to install the AFCB's aboard N40 for an extended evaluation period.

5. Installation of AFCB Test System On N40

The electrical installation shall be completed in accordance with drawing number 9854415 under the guidance of the WJHTC Electrical Systems Designated Engineering Representative (DER), Code ACT-370. The mechanical installation shall be completed under the guidance of the WJHTC Mechanical Systems DER, Code ACT-370.

The following list contains general instructions for completing the installation (Full installation instructions are contained in the AFCB Ground Test Checkout Report). The installation shall be completed in accordance with all existing safety requirements and the necessary approvals shall be obtained in advance of starting the installation.

- ❑ The two AFCI-JB Interface wire harnesses, P-18 and P-6, shall be connected to the thermal circuit breakers in accordance with FAA Drawing number 9854415.

  Harness P-18 shall be connected to the:

  - Left Inboard Landing Lights (7.5A)
  - Navigation Lights (5A)
  - Window Lights (10A)
  - Left Ceiling Lights (15A)

  Harness P-6 shall be connected to the:

  - DME-2 (3A)
  - Auxiliary Pitot Heat (5A)
  - First Officers Window (5A)
  - AC Project Power (15A)
- ❑ Mount the AFCI-JB in the flight deck as per the Mechanical Systems DER instructions.
- ❑ Mount the Odyssey and the BNC Breakout Box in the cabin rack per the Mechanical Systems DER instructions.
- ❑ Insure that all mounting is secure.
- ❑ Route the AFCI-JB harnesses and the AFCI-JB/Breakout Box harness. Do not mate the harnesses to the AFCI-JB or the breakout box until electrical tests have been completed. Do not secure the harness until electrical tests have been completed.

6. Arc Fault Troubleshooting – General Background

Although AFCB's can detect arcing on the circuit in which it is installed, it cannot determine the location of the arc along the circuit. Furthermore, means for easily troubleshooting an arc fault after and AFCB trip are under development but not currently available. This plan has been developed to establish a procedure for troubleshooting AFCB trips, should they occur.

An understanding of current methods of troubleshooting thermal trips will clarify the additional measures needed to troubleshoot an AFCB trip and specifically the procedures that will be followed during the FAA AFCB flight test program.

Troubleshooting circuit breakers is an iterative process. Generally, after a thermal circuit breaker trip, troubleshooting begins by evaluating the load(s) powered by the circuit. The load is either tested for correct operation, or is removed and replaced if its correct operation cannot be directly determined. The circuit is powered and if no additional trips are noted the corrective action is considered complete.

If additional trips of the same circuit occur, there are several options for corrective action. The load may still be suspected, and the problem may not be reproducible on the ground. The circuit breaker itself may be suspect and replaced (tripping of thermal circuit breakers under normal conditions, or failure of a circuit breaker to stay closed when depressed, are two common circuit breaker failure modes). Usually, the last item to be checked is the circuit wiring, mainly because of the inherent difficulties in testing and inspecting the wiring.

AFCB's add another dimension of complexity to the troubleshooting problem. AFCB's have two trip modes, thermal (current overload) and arc fault. There are unique procedures for troubleshooting each mode, and unfortunately, if one procedure fails to identify the problem it may be necessary to complete the other procedure to be certain that the problem has been resolved. Future AFCB's will have the ability to indicate if the trip mode was thermal or arc fault related. The prototypes flown in this test program will not have this feature. However, the data recording instrumentation will be triggered by the AFCB's arc fault detection circuit and therefore it will be known with certainty if the trip mode was thermal versus arc fault.

If the trip mode was arc fault related, the question remains was the arc trip a real arc or was it a nuisance trip? The instrumentation being used in these flights will record the current waveforms immediately before and after the AFCB indicates that an arc is present and a trip is initiated. This data will be analyzed by Eaton Aerospace to determine if it appears to be a real arc or a nuisance trip. If it is certain that the trip was nuisance related, then the breaker will be reset and flights testing may resume. If a nuisance trip is not certain, then further diagnostics will be required.

Provisions have been made to baseline the condition of the wiring on the eight circuits that will be used in the tests with Time Domain Reflectometry (TDR). During ground testing of the AFCB test system, each AFCB equipped circuit will be characterized with TDR. This data will form a baseline measurement against which future measurements will be compared. Changes in the measurement indicate possible locations at which the arcing may have occurred.

At this point, it is unclear if TDR is sensitive enough to detect the damage incurred by a wire during an arcing condition. If the TDR fails to identify the location of the fault, visual inspection of the circuit must be performed to determine the source of the fault.

7. Detailed Troubleshooting Procedures

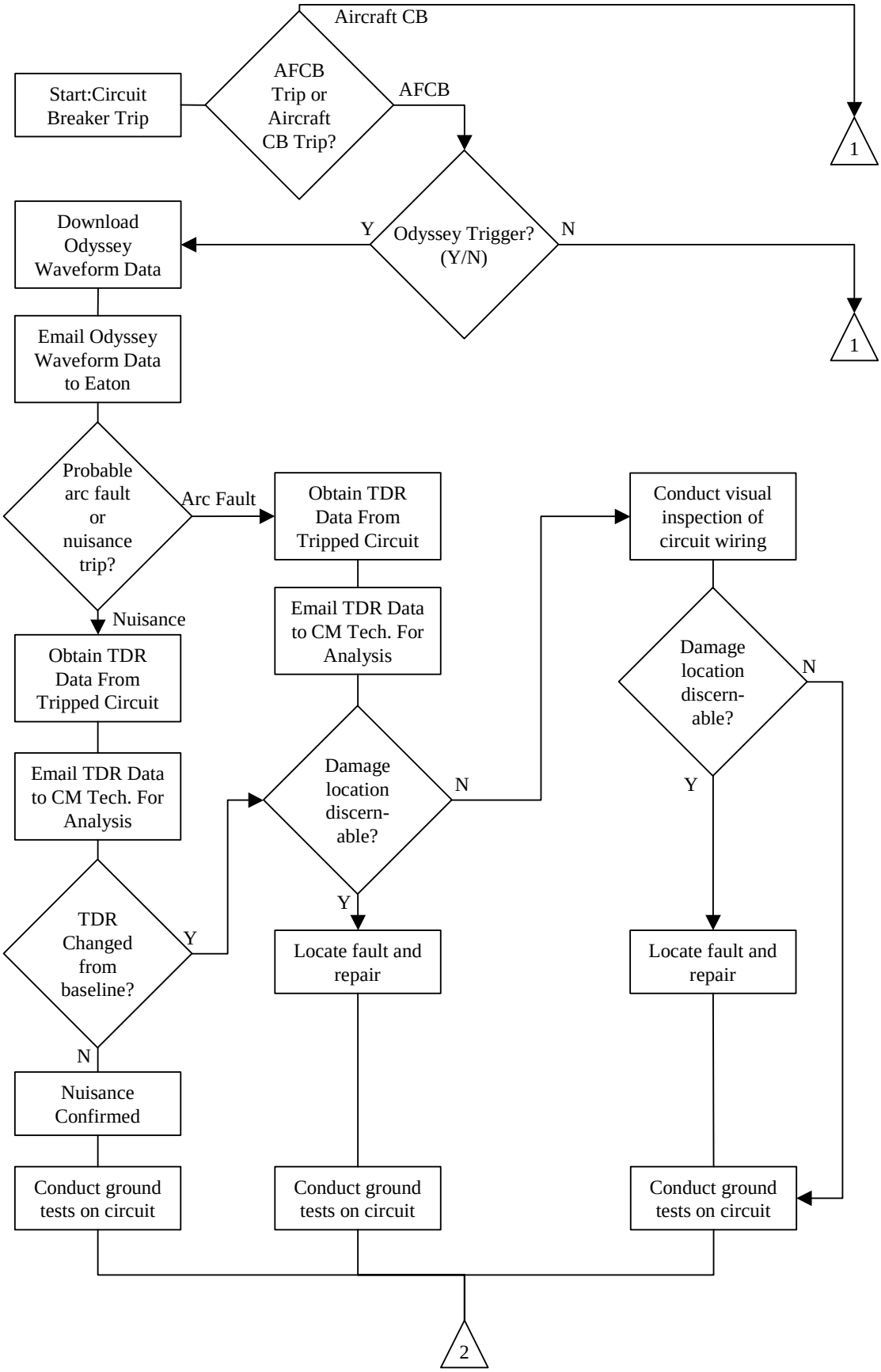
All troubleshooting shall be performed by qualified FAA personnel under the direction of the Electrical Systems DER, Code ACT-370.

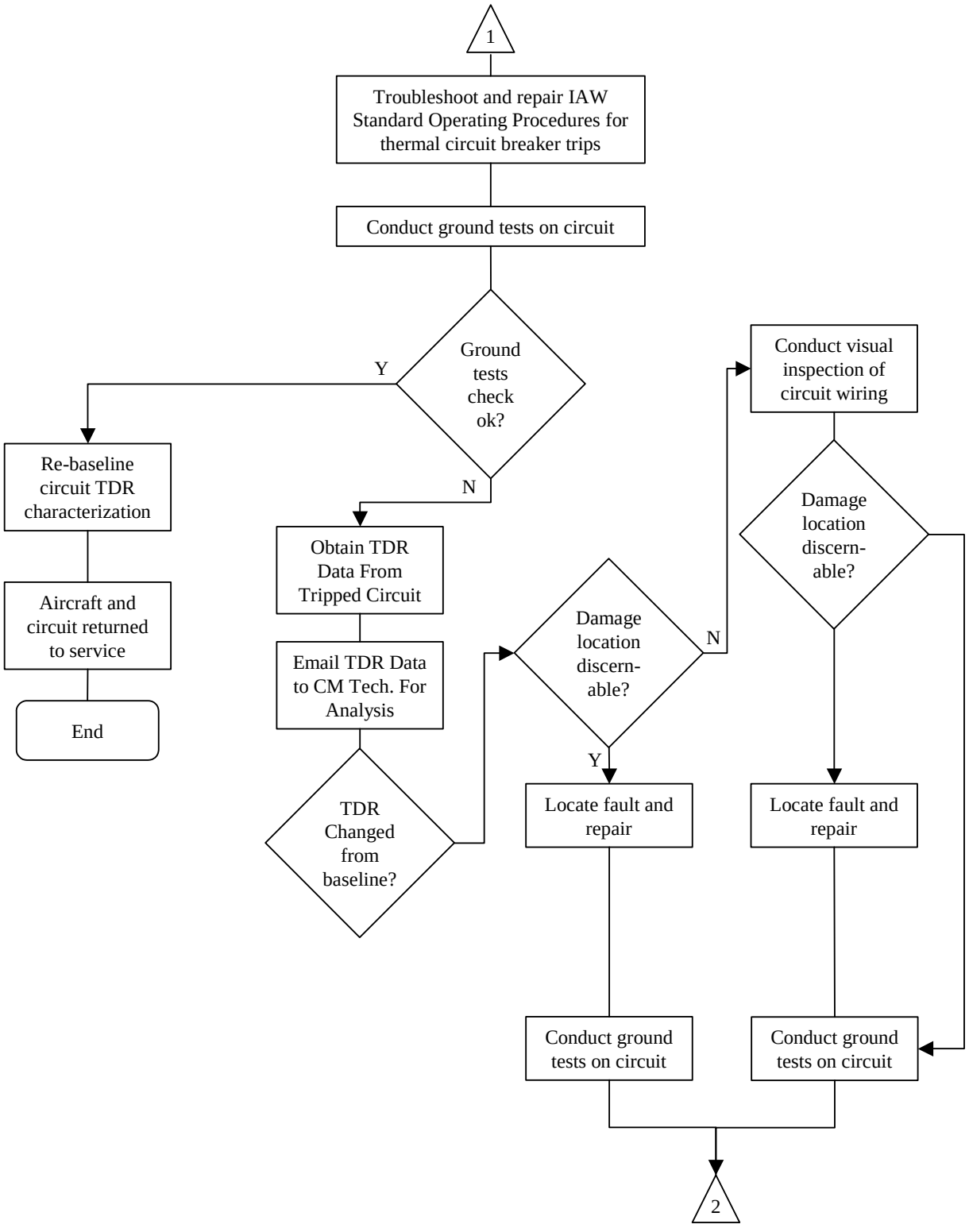
Upon an AFCB arc fault trip, the Odyssey data recording system will record the current and voltage waveforms from the eight circuits equipped with AFCB's. A thermal trip of the AFCB or the aircraft circuit breaker will not cause the Odyssey to trigger on and record this data. Therefore, it will be known immediately if the trip was caused by an arc fault.

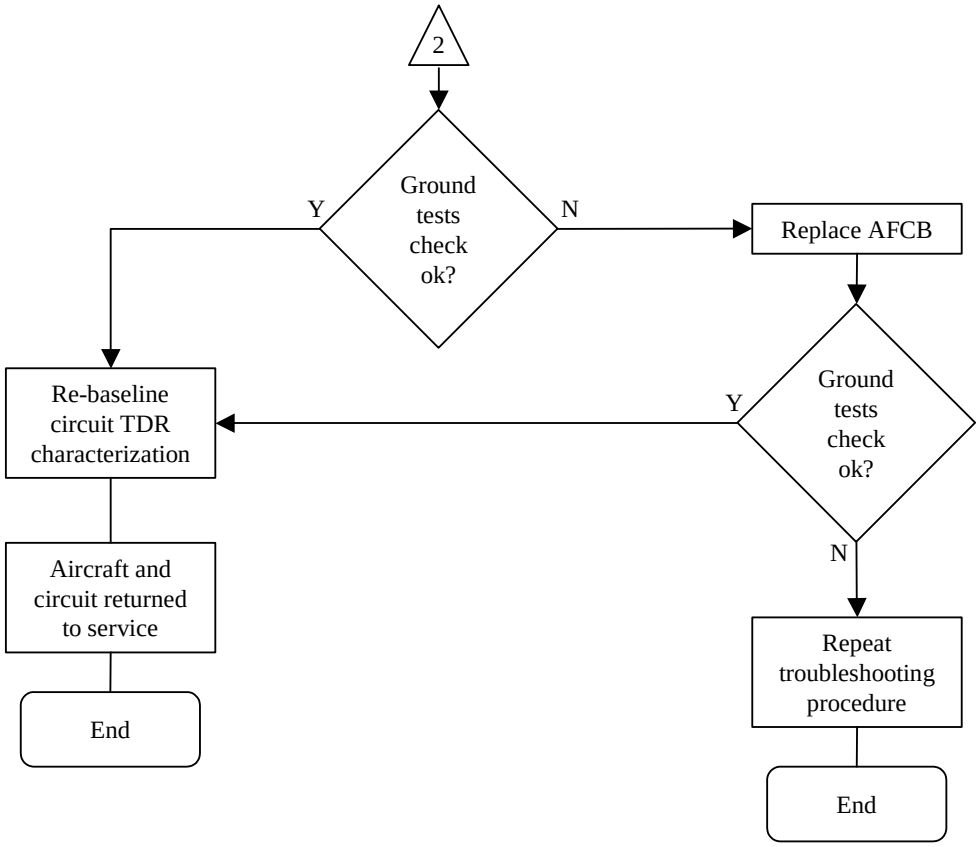
Appendix A contains the detailed process flow charts.

Appendix A

Troubleshooting Process Flowcharts


Start:Circuit Breaker Trip
AFCB Trip or Aircraft CB Trip?
Aircraft CB
AFCB
1
Odyssey Trigger? (Y/N)
Y
N
Download Odyssey Waveform Data
Email Odyssey Waveform Data to Eaton
Probable arc fault or nuisance trip?
Arc Fault
Nuisance
Obtain TDR Data From Tripped Circuit
Email TDR Data to CM Tech. For Analysis
TDR Changed from baseline?
Damage location discern-able?
Conduct visual inspection of circuit wiring
Locate fault and repair
Nuisance Confirmed
Conduct ground tests on circuit
2


1
Troubleshoot and repair IAW Standard Operating Procedures for thermal circuit breaker trips
Conduct ground tests on circuit
Ground tests check ok?
Y
N
Re-baseline circuit TDR characterization
Aircraft and circuit returned to service
End
Obtain TDR Data From Tripped Circuit
Email TDR Data to CM Tech. For Analysis
TDR Changed from baseline?
Damage location discern-able?
N
Y
Conduct visual inspection of circuit wiring
Damage location discern-able?
Locate fault and repair
Locate fault and repair
Conduct ground tests on circuit
Conduct ground tests on circuit
2


2
Ground tests check ok?
Y
N
Replace AFCB
Ground tests check ok?
Y
N
Re-baseline circuit TDR characterization
Aircraft and circuit returned to service
End
Repeat troubleshooting procedure
End

APPENDIX F—HENDRY FLIGHT TEST PLAN

Arc Fault Circuit Breaker
Flight Test Program

Flight Test Plan

for

Hendry Arc Fault Circuit Breaker (AFCB) Installation

on

FAA Technical Center
Boeing 727-25C Aircraft N40

27 June 2002

FAA William J. Hughes Technical Center
Engineering and Modification Section, ACT-370
Maintenance, Inspection, and Repair Section, AAR-480

Prepared by: R.A. Pappas, AAR-480

Reviewed by: J. Beres, ACT-370

Approved by: Armando Gaetano
Manager, Engineering & Modifications Section, ACT-370

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1.0 INTRODUCTION

This document defines the flight test procedures for evaluating the performance of Arc Fault Circuit Breakers (AFCBs) in an FAA owned Boeing 727-25C aircraft. The effort will be conducted by the United States (U.S.) Federal Aviation Administration (FAA) at the William J. Hughes Technical Center (WJHTC), Atlantic City, New Jersey.

1.1 BACKGROUND

The integration of arc fault detection into circuit breakers represents a revolutionary change in circuit protection; which has changed little in the last thirty to forty years. There is abundant evidence of arc faults in all types of aircraft. Laboratory data clearly demonstrates that the current generated during an arcing fault can be very high, yet quite intermittent. The bimetallic elements in thermal breakers do not react quickly enough, if at all, to this ticking arc fault condition. If left unchecked, the arcing condition can develop into an arc tracking condition, potentially destroying a major portion of, or an entire wire bundle. Arcing can also result in many other serious safety hazards.

In 1999, the FAA and the Navy established a joint R&D project to develop aircraft AFCBs. The goal of this effort is to develop a circuit breaker that integrates arc fault protection together with existing thermal protection into a form, fit, and functional replacement of existing thermal circuit breakers. In laboratory testing, the AFCB prototypes have been very effective in the detection of arcing faults.

In contrast to thermal breakers, which are passive in nature, AFCBs actively monitor the circuits on which they are installed. Due to the nature of electrical systems, there are times when a normal condition may 'look' similar to an arc fault. When such a condition trips an arc fault circuit breaker, it is defined as a nuisance trip. AFCB designs minimize the occurrence of nuisance tripping and maximize sensitivity to arc fault detection.

To address nuisance tripping, the FAA, Navy, and the AFCB developers, have conducted extensive tests to characterize the normal operation of electrical loads, and perturbations to electrical systems during normal events such as bus transfers, power on/off, transfer of power sources, etc. Laboratory tests today have provided a high level of confidence that nuisance tripping of AFCBs is being successfully controlled.

AFCB development has progressed to the point where flight tests are appropriate to demonstrate compliance with applicable Federal Aviation Regulations (FARs).

1.2 OBJECTIVE

The objective of this task is to conduct an in-flight evaluation of AFCB performance.

The Federal Aviation Administration (FAA), William J. Hughes Technical Center (WJHTC) R&D Flight Program is performing a minor modification to their Boeing 727-25C aircraft. This temporary modification involves the installation of eight AFCB prototypes manufactured by the Hendry corporation. The AFCBs are to be installed for a six-month evaluation period in support of AFCB research and development.

1.3 SCOPE

The scope of this effort is to install AFCBs manufactured by the Hendry corporation in an FAA owned Boeing 727-25C aircraft and conduct a flight evaluation of the developmental AFCBs. Data recorded includes line voltage, load voltage, and current for each of the installed breakers. Data reduction efforts of any occurring arc faults will include identification of relationships between the trip conditions.

2.0 FLIGHT TEST GOALS

The following list describes the goals of the experimental flight test program, listed in order of importance.

- Complete fifty (50) or more hours of developmental flight test evaluation but not less than twenty-five (25) hours. Data generated during these flights is critical to the AFCB research and development program and for obtaining approval of the N-40 one-only STC.
- Evaluate the operation of the arc fault circuit breakers under standard B727 operational procedures.
- Evaluate the operation of the AFCB instrumentation and Odyssey data recording system for future unmanned data collection.

3.0 SYSTEM DESCRIPTION

The equipment being installed for the Arc Fault flight evaluation includes developmental prototype AFCBs installed in a junction box, an instrumentation recorder and interconnecting cables and wire harnesses. These items are described in the following paragraphs.

3.1 ARC FAULT CIRCUIT BREAKERS

Eight (8) - Hendry prototype arc fault circuit breakers of the following ratings: one 2.5 A, three 5A, one 7.5A, one 10A, and two 15A (mounted in AFCI Junction Box).

3.2 ARC FAULT CIRCUIT INTERUPTER - JUNCTION BOX AND AIRCRAFT HARNESSES

One (1) – AFCI-JB.
Two (2) – AFCI-JB Test Unit wire harnesses, P18 and P6

3.3 INSTRUMENTATION EQUIPMENT

One (1) - 24 channel, Nicolet Odyssey data recorder.
One (1) – BNC Breakout Box.
One (1) – AFCI JB – BNC Breakout Box Interface Harness.
Twenty-four (24) – 24-inch BNC connector cables.
One (1) – Trigger Alarm

3.4 AIRCRAFT INTERFACES

The electrical connections for the system are shown schematically in FAA Drawing Number 9854415, Arc Fault Circuit Breaker Wiring. The AFCBs mounted within the AFCI-JB will be electrically in series with the load side of the existing circuit breakers. The AFCI-JB wire harnesses, P-18 and P-6, connect the load side of the each aircraft circuit breaker to the line side

of the respective AFCB and from the load side of the each AFCB to the feed wire for the respective load.

It is important to note that the AFCBs will be connected in series with the load side of the existing thermal circuit breakers. In other words, current circuit protection aboard the aircraft will not be compromised in any way by this installation.

The on-board Project Power Inverter provides 120VAC 60Hz power for the Data Acquisition System.

4.0 AIRCRAFT INSTALLATION

The AFCBs will be installed in an Arc Fault Circuit Interrupter-Junction Box (AFCI-JB) that will enclose all the AFCBs and required instrumentation interfaces. The AFCI-JB will be mounted in the rear, left side of the cockpit. The test unit will have bypass switches that will disable the AFCBs if desired.

The BNC Breakout Box and the Odyssey data recorder will be mounted in the cabin of the aircraft.

The electrical installation shall be completed in accordance with drawing number 9854415 under the guidance of the WJHTC Electrical Systems Designated Engineering Representative (DER. The mechanical installation shall be completed under the guidance of the WJHTC Mechanical Systems DER.

Detailed instructions for completing the installation can be found in the AFCB Ground Checkout Procedures Report.

5.0 CERTIFICATION REQUIREMENTS

There are no FAA Technical Standard Orders for the equipment being installed during this modification. Experimental flight test is being performed to collect data necessary to obtain a one only STC to install the AFCBs aboard N40 for an extended evaluation period.

6.0 FLIGHT TEST PROFILE REQUIREMENTS

N40 will be operated in conformance with Standard B727 Operations. The purpose of the flight test is to maximize the number of flight hours. Duration and distance of flights will be at the discretion of the pilot in command and within the operating restrictions established by the MIDO.

No excessive cycling of the aircraft is necessary.

As established by the MIDO, flight restrictions shall be removed to the maximum extent possible upon completion of flight hour thresholds established by the MIDO.

If possible, the aircraft will fly to Santa Barbara, California to permit Hendry engineers an opportunity to assess the AFCB installation aboard the aircraft. A flight to Seattle, Washington will also be conducted, if possible, to permit FAA Transport Directorate, ANM-100 engineers to observe the installation.

7.0 LIMITATIONS

It is proposed that the first 5 flight hours (Phase 1) be conducted within a 100-mile radius from Atlantic City International Airport. Upon satisfactory completion of this 5-hour period, it is requested that the remainder of the flights be conducted without restrictions (Phase 2).

An ACT-370 Safety Officer will be on all Phase 1 flights.

An AAR-480 engineer (or designee) must be aboard the aircraft during all AFCB flight tests to operate the Odyssey data recorder.

No AFCB equipped circuit shall be operated in-flight after an AFCB trip on the circuit, unless the pilot in command orders the operation of the circuit during an emergency. In this case, the flight engineer shall switch the associated bypass switch on the AFCI-JB to the bypass position. In addition, after an AFCB trip, the Flight Engineer shall pull the associated circuit breaker on the aircraft circuit breaker panel. Troubleshooting shall be performed in accordance with the AFCB Troubleshooting Procedures.

If there are two or more AFCB trips on a single electrical bus, the flight test shall be terminated and the aircraft will return to base immediately.

Limitations established by the MIDO shall be adhered to.

8.0 EMERGENCY PROCEDURES

In the event of an emergency (related or unrelated to the AFCB testing), the following procedures will be followed if ordered by the pilot in command.

The flight engineer shall bypass all AFCBs by closing the AFCB bypass switches on the AFCI-JB located behind the Captains chair.

- The flight engineer will set each AFCB to the open position.
- The Odyssey data recorder will be powered off by the engineer operating the system.

If power must be removed from the AFCI-JB the following steps will be completed:

- The flight engineer will open the eight circuit breakers on the aircraft circuit breaker panels. A colored button or other tag will uniquely identify these breakers. The eight circuit breakers and their respective locations are summarized in Table 1 below.

Table 1 – AFCB Test Circuit Breaker Locations

AFCB Circuit#	CB Identity	Panel/Location	Rating (Amps)	Bus
1	Left Inboard Landing Lights	P18-4 Lighting	7	115VAC Bus No. 1
2	Navigation Lights	P18-4 Lighting	5	115VAC Bus No. 2
3	Window Lights	P18-3 Lighting and Passenger Accommodations	10	115VAC Transfer Bus
4	Left Ceiling Lights	P18-3 Lighting and Passenger Accommodations	15	115VAC Transfer Bus
5	DME-2	P18-3 Electronic Load Circuit Breaker	3	115VAC Radio Bus No. 2
6	Heater-Pitot-Aux	P6-1 Miscellaneous AC, Anti-Ice & Rain	5	115VAC Bus No. 2
7	First Officers Window 4 & 5	P6-1 Miscellaneous AC, Anti-Ice & Rain	5	115 VAC Bus No. 3
8	Project Power	Project Power Junction Box	10	115VAC Bus No. 2

9.0 NORMAL PROCEDURES

9.1 PREFLIGHT

- ❑ Review flight plan with flight crew and all passengers.
- ❑ Review emergency procedures with flight crew and all passengers.
- ❑ Review all normal procedures with flight crew and all passengers.
- ❑ Flight engineer set all bypass switches on the AFCI-JB to normal except S8 (leave in BYPASS) and S1. Leave S1 in BYPASS until Landing light is on, then switch S1 to NORMAL.
- ❑ Apply power to the aircraft (Ground power or APU).
- ❑ Flight engineer close all AFCBs.
- ❑ Turn Odyssey data recorder to ON and wait for system to boot up and initialize. Start recording. Note the date, time, and recording number.
- ❑ If on ground power, start APU. Start Odyssey data recording and instruct flight engineer to transfer power from ground power to APU power. Record the date, time, and filename of the recording in the test logbook. Note that the recording was a ground power to APU transfer.
- ❑ If on APU power, start aircraft engines. Continue Odyssey data recording and instruct flight engineer to transfer power from APU to engine generators. Record the date, time, and filename of the recording in the test logbook. Note that the recording was an APU to engine generator power transfer.
- ❑ Continue the Odyssey data recording. Data will be recorded at the slow rate, 1kHz. Note the date, time, and filename in the test logbook. Also note the general conditions (weather, etc.) at this time.
- ❑ Proceed to flight phase in accordance with standard B727 start-up procedures.

9.2 FLIGHT

- ❑ Monitor Odyssey data recording system. The visual and aural trigger alarm mounted adjacent to the Odyssey data recorder will initiate when an AFCB has tripped and the Odyssey data recorder will automatically begin recording at the high sampling rate, 100kHz.
- ❑ If the trigger-alarm sounds, press the red reset button mounted on the trigger alarm enclosure to silence the trigger and extinguish the trigger alarm lights.
- ❑ Note the date, time, and the number of the AFCB(s) that caused the trigger. Also note the flight conditions and other information pertinent to the trigger event in the test logbook. Also note the new file name in the logbook with the start time of the recording.

9.3 POSTFLIGHT

- ❑ Continue to follow the flight procedures.
- ❑ Prior to engine shutdown, start APU or apply ground power. Switch aircraft power to APU or ground power. Shut engines in accordance with standard B727 operational procedures.
- ❑ Download data files from the Odyssey data recorder
- ❑ Shutdown the Odyssey data recorder.
- ❑ Shutdown aircraft in accordance with standard B727 operational procedures.

- - End of flight test procedures. - -

APPENDIX G—HENDRY GROUND CHECKOUT PROCEDURES

Arc Fault Circuit Breaker
Flight Test Program

Ground Checkout Procedures

for

Hendry
115 VAC Single Phase
Arc Fault Circuit Breaker (AFCB) Installation

on

FAA Technical Center
Boeing 727-25C Aircraft N40

18 June 2002

FAA William J. Hughes Technical Center
Engineering and Modification Section, ACT-370
Maintenance, Inspection, and Repair Section, AAR-480

Prepared by: R.A. Pappas, AAR-480

Reviewed by: J. Beres, ACT-370

Approved by: Armando Gaetano
Manager, Engineering & Modifications Section, ACT-370

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APPENDIX C – TIME DOMAIN REFLECTOMETRY BASELINE TEST PROCEDURES / VERIFICATION SHEET 21

1. INTRODUCTION

This document defines the procedures for installing Arc Fault Circuit Breakers (AFCBs) in an FAA owned Boeing 727-25C aircraft and performing a ground test prior to a flight evaluation of the AFCBs. The effort will be conducted by the United States (U.S.) Federal Aviation Administration (FAA) at the William J. Hughes Technical Center (WJHTC), Atlantic City, New Jersey.

1.1 BACKGROUND

The integration of arc fault detection into circuit breakers represents a revolutionary change in circuit protection; which has changed little in the last thirty to forty years. There is abundant evidence of arc faults in all types of aircraft. Laboratory data clearly demonstrates that the current generated during an arcing fault can be very high, yet quite intermittent. The bimetallic elements in thermal breakers do not react quickly enough, if at all, to this ticking arc fault condition. If left unchecked, the arcing condition can develop into an arc tracking condition, potentially destroying a major portion of, or an entire wire bundle. Arcing can also result in many other serious safety hazards.

In 1999, the FAA and the Navy established a joint R&D project to develop aircraft AFCBs. The goal of this effort is to develop a circuit breaker that integrates arc fault protection together with existing thermal protection into a form, fit, and functional replacement of existing thermal circuit breakers. In laboratory testing, the AFCB prototypes have been very effective in the detection of arcing faults.

In contrast to thermal breakers, which are passive in nature, AFCBs actively monitor the circuits on which they are installed. Due to the nature of electrical systems, there are times when a normal condition may 'look' similar to an arc fault. When such a condition trips an arc fault circuit breaker, it is defined as a nuisance trip. AFCB designs minimize the occurrence of nuisance tripping and maximize sensitivity to arc fault detection.

To address nuisance tripping, the FAA, Navy, and the AFCB developers, have conducted extensive tests to characterize the normal operation of electrical loads, and perturbations to electrical systems during normal events such as bus transfers, power on/off, transfer of power sources, etc. Laboratory tests today have provided a high level of confidence that nuisance tripping of AFCBs is being successfully controlled.

AFCB development has progressed to the point where flight tests are appropriate to demonstrate compliance with applicable Federal Aviation Regulations (FARs).

1.2 OBJECTIVE

The objective of this task is to conduct an in-flight evaluation of AFCB performance.

The Federal Aviation Administration (FAA), William J. Hughes Technical Center (WJHTC) R&D Flight Program is performing a minor modification to their Boeing 727-25C aircraft. This temporary modification involves the installation of eight AFCB prototypes manufactured by the

Hendry Corporation. The AFCBs are to be installed for a six-month evaluation period in support of AFCB research and development.

1.3 SCOPE

The scope of this effort is to install AFCBs manufactured by Hendry in an FAA owned Boeing 727-25C aircraft and conduct a flight evaluation of the developmental AFCBs. Data recorded includes line voltage, load voltage, and current for each of the installed breakers. Data reduction efforts of any occurring arc faults will include identification of relationships between the trip conditions.

2. CERTIFICATION REQUIREMENTS

The certification request will permit the FAA to temporarily install AFCBs aboard the B727-25C (N40) with the purpose of evaluating the circuit breakers, in-flight, over a six-month period. This will assure that the AFCBs are evaluated against a wide range of actual electrical conditions.

There are no FAA Technical Standard Orders for the equipment being installed during this modification. Experimental flight test is being performed to collect data necessary to obtain a one only STC to install the AFCBs aboard N40 for an extended evaluation period.

3. SYSTEM DESCRIPTION

The equipment being installed for the Arc Fault flight evaluation includes developmental prototype AFCBs installed in a junction box, an instrumentation recorder and interconnecting cables and wire harnesses. These items are described in the following paragraphs.

3.1 ARC FAULT CIRCUIT BREAKERS

Eight (8) - Hendry prototype arc fault circuit breakers of the following ratings: one 2.5 A, three 5A, one 7.5A, one 10A, and two 15A (mounted in AFCI Junction Box).

3.2 ARC FAULT CIRCUIT INTERRUPTER - JUNCTION BOX AND AIRCRAFT HARNESSES

One (1) – AFCI-JB.
Two (2) – AFCI-JB Test Unit wire harnesses, P18 and P6

3.3 INSTRUMENTATION EQUIPMENT

One (1) - 24 channel, Nicolet Odyssey data recorder.
One (1) – BNC Breakout Box.
One (1) – AFCI JB – BNC Breakout Box Interface Harness.
Twenty-four (24) – 24-inch BNC connector cables.
One (1) – Trigger Alarm

3.4 AIRCRAFT INTERFACES

The electrical connections for the system are shown schematically in FAA Drawing Number 9854415, Arc Fault Circuit Breaker Wiring. The AFCBs mounted within the AFCI-JB will be electrically in series with the load side of the existing circuit breakers. The AFCI-JB wire harnesses, P-18 and P-6, connect the load side of the each aircraft circuit breaker to the line side of the respective AFCB and from the load side of the each AFCB to the feed wire for the respective load.

3.5 POWER REQUIREMENTS

120VAC 60Hz power is required for power to the Data Acquisition System. The on board Project Power Inverter provides this power.

4. AIRCRAFT INSTALLATION

The electrical, system, and mechanical integration of this installation will be accomplished at Atlantic City International Airport (ACIAP) using FAA technical and engineering personnel. The engineering personnel have been granted authority to approve "electrical systems" and "structures" data via FAA Form 8110-3, by the New York Aircraft Certification Office (NYACO).

The AFCBs will be installed in an Arc Fault Circuit Interrupter-Junction Box (AFCI-JB) that will enclose all the AFCBs and required instrumentation. The AFCBs will not be mounted in the aircraft circuit breaker panels. It is important to note that the AFCBs will be connected in series with the load side of the existing thermal circuit breakers. In other words, current circuit protection aboard the aircraft will not be compromised in any way by this installation.

The AFCI-JB will contain the eight AFCB units. The AFCI-JB will be mounted on the floor in the rear, left side of the flight deck. The test unit will have by-pass switches that will disable the AFCBs if desired. The test unit will be fabricated using standard best practices and in accordance with AC 43.13-1B and contain any possible AFCB failure.

The electrical installation shall be completed in accordance with drawing number 9854415 under the guidance of the WJHTC Electrical Systems Designated Engineering Representative (DER). The mechanical installation shall be completed under the guidance of the WJHTC Mechanical Systems DER.

4.1 AFCB INSTALLATION INSTRUCTIONS

The installation shall be completed in accordance with all existing safety requirements and the necessary approvals shall be obtained in advance of starting the installation.

General instructions for completing the installation can be found at Appendix A.

4.2 INSTRUMENTATION EQUIPMENT INSTALLATION INSTRUCTIONS

The BNC Breakout Box and the Odyssey data recorder will be mounted in the cabin of the aircraft. The AFCI-JB/BNC Breakout Box Interface Harness connects the AFCI-JB to the BNC

Breakout Box. The 24 BNC connectors on the BNC Breakout Box are connected to the Odyssey data recorder with 24" BNC coaxial cables.
General instructions for completing the installation can be found at Appendix A.

5. GROUND CHECKOUT PROCEDURES

After completion of the installation the following tests shall be conducted to demonstrate that the AFCB equipment was successfully integrated and operates properly.

5.1 AFCB ELECTRICAL TESTS

After the mechanical and electrical installation of the AFCB equipment has been accomplished the electrical tests presented at Appendix B shall be successfully completed and the results documented to support certification.

5.2 AFCB TEST CIRCUIT TIME DOMAIN REFLECTOMETRY BASELINE TESTS

Time Domain Reflectometry Baseline Tests to characterize the test circuits were performed during the previous series of flight tests using AFCBs from another manufacturer. Since the same test circuits are being used for this test the TDR Baseline Tests will not be performed. The procedures for these tests are shown at Appendix C. If, during integration and other testing, it is determined that a repeat of the TDR testing is required the equipment and contractor are available to support this series of tests.

- - End of Ground Checkout Procedure - -

APPENDIX A – AFCB INSTALLATION INSTRUCTIONS / VERIFICATION SHEET

The installation shall be completed in accordance with all existing safety requirements and the necessary approvals shall be obtained in advance of starting the installation. The following are general instructions for completing the installation. Record completion and any observations in the Completed/Comments column.

Step	Procedure	Completed/Comments
1	The two AFCI-JB Interface wire harnesses, P-18 and P-6, shall be connected to the thermal circuit breakers in accordance with FAA Drawing number 9854415. Harness P-18 shall be connected to the following four aircraft circuits: 1. Left Inboard Landing Lights (7.5A) 2. Navigation Lights (5A) 3. Window Lights (10A) 4. Left Ceiling Lights (15A) Harness P-6 shall be connected to the following four aircraft circuits: 1. DME-2 (3A) 2. Auxiliary Pitot Heat (5A) 3. First Officers Window (5A) 4. AC Project Power (15A)	
2	Mount the AFCI-JB in the flight deck as per the Mechanical Systems DER instructions.	
3	Mount the Odyssey and the BNC Breakout Box in the cabin rack per the Mechanical Systems DER instructions.	
4	Insure that all mounting is secure.	
5	Route the AFCI-JB harnesses and the AFCI-JB/Breakout Box harness. Do not mate the harnesses to the AFCI-JB or the breakout box until electrical tests have been completed. Do not secure the harness until electrical tests have been completed.	

- - End of Detailed Installation Instructions - -

Installation completed by _____ Verified by _____
Name and Date Name and Date

APPENDIX B - AFCB ELECTRICAL TEST PROCEDURES / VERIFICATION SHEET

The following Electrical Test Procedures shall be conducted to verify that there is continuity and no shorts in the AFCB project equipment and aircraft wiring. Record completion and any observations in the Completed/Comments column.

Step	Procedure	Completed/Comments
1	Open the eight (8) aircraft circuit breakers for the circuits being monitored during the AFCB Flight Test Program	
2	Confirm that the P-18 and P-6 harnesses from the aircraft circuit breaker panels to P1 and P2 on the AFCI-JB are disconnected from the AFCI-JB.	
3	Prior to connecting the harnesses to the AFCI-JB, perform the following continuity and isolation checks performed in accordance with Table 1.	

Table 1 – AFCI-JB Checkout

AFCI-JB Connector Test Points	AFCB-x Position (Open/Closed) (x =1,2,3,4,5,6,7,8)	AFCB By-Pass Switch S-x (Normal/Bypass) (x = 1,2,3,4,5,6,7,8)	Expected Test Point Condition	Observed Condition (see Note)
P1, 1 and 2	AFCB-1, Closed	S-1, Normal	Short	
P1, 4 and 5	AFCB-2, Closed	S-2, Normal	Short	
P1, 7 and 8	AFCB-3, Closed	S-3, Normal	Short	
P1, 10 and 11	AFCB-4, Closed	S-4, Normal	Short	
P2, 1 and 2	AFCB-5, Closed	S-5, Normal	Short	
P2, 4 and 5	AFCB-6, Closed	S-6, Normal	Short	
P2, 7 and 8	AFCB-7, Closed	S-7, Normal	Short	
P2, 10 and 11	AFCB-8, Closed	S-8, Normal	Short	
P1, 1 and 2	AFCB-1, Open	S-1, Normal	Open	
P1, 4 and 5	AFCB-2, Open	S-2, Normal	Open	
P1, 7 and 8	AFCB-3, Open	S-3, Normal	Open	
P1, 10 and 11	AFCB-4, Open	S-4, Normal	Open	
P2, 1 and 2	AFCB-5, Open	S-5, Normal	Open	
P2, 4 and 5	AFCB-6, Open	S-6, Normal	Open	
P2, 7 and 8	AFCB-7, Open	S-7, Normal	Open	
P2, 10 and 11	AFCB-8, Open	S-8, Normal	Open	
P1, 1 and 2	AFCB-1, Open	S-1, Bypass	Short	
P1, 4 and 5	AFCB-2, Open	S-2, Bypass	Short	

P1, 7 and 8	AFCB-3, Open	S-3, Bypass	Short	
P1, 10 and 11	AFCB-4, Open	S-4, Bypass	Short	
P2, 1 and 2	AFCB-5, Open	S-5, Bypass	Short	
P2, 4 and 5	AFCB-6, Open	S-6, Bypass	Short	
P2, 7 and 8	AFCB-7, Open	S-7, Bypass	Short	
P2, 10 and 11	AFCB-8, Open	S-8, Bypass	Short	
AFCB-1, Red & Black Banana Plug Sockets	AFCB-1, Closed	S-1, Normal	Short	
AFCB-2, Red & Black Banana Plug Sockets	AFCB-2, Closed	S-2, Normal	Short	
AFCB-3, Red & Black Banana Plug Sockets	AFCB-3, Closed	S-3, Normal	Short	
AFCB-4, Red & Black Banana Plug Sockets	AFCB-4, Closed	S-4, Normal	Short	
AFCB-5, Red & Black Banana Plug Sockets	AFCB-5, Closed	S-5, Normal	Short	
AFCB-6, Red & Black Banana Plug Sockets	AFCB-6, Closed	S-6, Normal	Short	
AFCB-7, Red & Black Banana Plug Sockets	AFCB-7, Closed	S-7, Normal	Short	
AFCB-8, Red & Black Banana Plug Sockets	AFCB-8, Closed	S-8, Normal	Short	
AFCB-1, Red & Black Banana Plug Sockets	AFCB-1, Open	S-1, Normal	Open	
AFCB-2, Red & Black Banana Plug Sockets	AFCB-2, Open	S-2, Normal	Open	
AFCB-3, Red & Black Banana Plug Sockets	AFCB-3, Open	S-3, Normal	Open	
AFCB-4, Red & Black Banana Plug Sockets	AFCB-4, Open	S-4, Normal	Open	
AFCB-5, Red & Black Banana Plug Sockets	AFCB-5, Open	S-5, Normal	Open	

AFCB-6, Red & Black Banana Plug Sockets	AFCB-6, Open	S-6, Normal	Open	
AFCB-7, Red & Black Banana Plug Sockets	AFCB-7, Open	S-7, Normal	Open	
AFCB-8, Red & Black Banana Plug Sockets	AFCB-8, Open	S-8, Normal	Open	
AFCB-1, Red & Black Banana Plug Sockets	AFCB-1, Open	S-1, Bypass	Short	
AFCB-2, Red & Black Banana Plug Sockets	AFCB-2, Open	S-2, Bypass	Short	
AFCB-3, Red & Black Banana Plug Sockets	AFCB-3, Open	S-3, Bypass	Short	
AFCB-4, Red & Black Banana Plug Sockets	AFCB-4, Open	S-4, Bypass	Short	
AFCB-5, Red & Black Banana Plug Sockets	AFCB-5, Open	S-5, Bypass	Short	
AFCB-6, Red & Black Banana Plug Sockets	AFCB-6, Open	S-6, Bypass	Short	
AFCB-7, Red & Black Banana Plug Sockets	AFCB-7, Open	S-7, Bypass	Short	
AFCB-8, Red & Black Banana Plug Sockets	AFCB-8, Open	S-8, Bypass	Short	

* Note - A measurement of 2.1 Megohms between test points will be seen when an open condition is expected. This is due to the voltage divider circuit added for instrumentation purposes.

Step	Procedure	Completed/Comments
4	Open the eight AFCBs in the AFCI-JB.	
5	On the AFCI-JB set S-1 through S-8 to Normal.	
6	Open the eight aircraft circuit breakers.	
7	With aircraft power off, connect harness P-18 to AFCI-JB connector P-1 and harness P-6 to AFCI-JB connector P2.	
8	Apply power (ground power or APU) to the aircraft.	
9	Close the eight aircraft circuit breakers and verify	

	that the associated loads are not energized.	
10	Set AFCI-JB S-1 to Bypass, turn on using the cockpit switch and verify via visual means that the LEFT INBOARD LANDING LIGHTS are operating. Set S-1 to Normal.	
11	Set AFCI-JB S-2 to Bypass, turn on using the cockpit switch and verify via visual means that the OSCILLATING NAVIGATION LIGHTS are operating. Set S-2 to Normal.	
12	Set AFCI-JB S-3 to Bypass, turn on using the cockpit switch and verify via visual means that the WINDOW LIGHTS – LEFT SIDE are operating. Set S-3 to Normal.	
13	Set AFCI-JB S-4 to Bypass, turn on using the cockpit switch and verify via visual means that the PASSENGER CEILING LIGHTS – LEFT SIDE are operating. Set S-4 to Normal.	
14	Set AFCI-JB S-5 to Bypass, turn on using the cockpit switch and verify via visual means that the DME-2 is operating. Set S-5 to Normal.	
15	Set AFCI-JB S-6 to Bypass, turn on using the cockpit switch and verify via the Pitot Ammeter that the HEATER-PITOT-AUX is operating. Set S-6 to Normal.	
16	Set AFCI-JB S-7 to Bypass, turn on using the cockpit switch and verify via visual means that the FIRST OFFICER'S WINDOW HEATER is operating. Set S-7 to Normal.	
17	Set AFCI-JB S-8 to Bypass, turn on using the cockpit switch and verify that the PROJECT POWER is operating. Set S-8 to Normal.	
18	Close AFCB-1, turn on using the cockpit switch and verify via visual means that the LEFT INBOARD LANDING LIGHTS are operating. Open AFCB-1.	
19	Close AFCB-2, turn on using the cockpit switch and verify via visual means that the OSCILLATING NAVIGATION LIGHTS are operating. Open AFCB-2.	
20	Close AFCB-3, turn on using the cockpit switch and verify via visual means that the WINDOW LIGHTS – LEFT SIDE are operating. Open AFCB-3.	
21	Close AFCB-4, turn on using the cockpit switch and verify via visual means that the PASSENGER CEILING LIGHTS – LEFT SIDE	

	are operating. Open AFCB-4.	
22	Close AFCB-5, turn on using the cockpit switch and verify via visual means that the DME-2 is operating. Open AFCB-5.	
23	Close AFCB-6, turn on using the cockpit switch and verify via the Pitot Ammeter that the HEATER-PITOT-AUX is operating. Open AFCB-6.	
24	Close AFCB-7, turn on using the cockpit switch and verify by via visual means that the FIRST OFFICER'S WINDOW HEATER is operating. Open AFCB-7.	
25	Close AFCB-8, turn on using the cockpit switch and verify that PROJECT POWER is operating. Open AFCB-8.	
26	Open the eight aircraft circuit breakers.	
27	Connect the P-3 connector on the AFCI-JB to P-4 on the BNC Breakout Box with the AFCI-JB/BNC Breakout Box Interface Harness.	
28	Using the 24" BNC connector cables, connect the BNC Breakout Box to the Odyssey data recorder in accordance with Table 2. For the eight channels noted in Table 2, install a 50-Ohm in-line terminator between the BNC cable and the Odyssey data recorder.	

Table 2 – Odyssey Channel Assignments

From BNC Breakout Box Connector BNC-x (x = 1,2,3…..22,23,24)	To Odyssey Data Recorder Channel Number x (x = 1,2,3…..22,23,24)	50-Ohm In-line Terminator Required? (Y/N)	Measurement Parameter Description
BNC-1	1	N	AFCB–1 Line Volts
BNC-9	9	N	AFCB-1 Load Volts
BNC-17	17	Y	AFCB-1 Current
BNC-2	2	N	AFCB–2 Line Volts
BNC-10	10	N	AFCB-2 Load Volts
BNC-18	18	Y	AFCB-2 Current
BNC-3	3	N	AFCB–3 Line Volts
BNC-11	11	N	AFCB-3 Load Volts
BNC-19	19	Y	AFCB-3 Current
BNC-4	4	N	AFCB–4 Line Volts
BNC-12	12	N	AFCB-4 Load Volts
BNC-20	20	Y	AFCB-4 Current
BNC-5	5	N	AFCB–5 Line Volts
BNC-13	13	N	AFCB-5 Load Volts
BNC-21	21	Y	AFCB-5 Current
BNC-6	6	N	AFCB–6 Line Volts
BNC-13	13	N	AFCB-6 Load Volts
BNC-22	22	Y	AFCB-6 Current
BNC-7	7	N	AFCB–7 Line Volts
BNC-14	14	N	AFCB-7 Load Volts
BNC-23	23	Y	AFCB-7 Current
BNC-8	Open	N	AFCB–8 Line Volts
BNC-15	15	N	AFCB-8 Load Volts
BNC-24	24	Y	AFCB-8 Current
Coax from AFCI-JB BNC-Trigger	8	N	Odyssey Trigger Input

Step	Procedure	Completed/Comments
28	Turn on the Odyssey data recorder. The Odyssey data recorder takes several minutes to complete the boot process.	
29	Close the eight aircraft circuit breakers. Verify that the voltage and current inputs to the data recorder are reading zero.	
30	Close AFCB-1, turn on using the cockpit switch and verify via visual means that the LEFT INBOARD LANDING LIGHTS are operating. Verify that the voltage and current waveforms are being properly measured on the Odyssey data recorder channels 1, 9, and 17.	
31	Close AFCB-2, turn on using the cockpit switch	

	and verify via visual means that the OSCILLATING NAVIGATION LIGHTS are operating. Verify that the voltage and current waveforms are being properly measured on the Odyssey data recorder channels 2, 10, and 18.	
32	Close AFCB-3, turn on using the cockpit switch and verify via visual means that the WINDOW LIGHTS – LEFT SIDE are operating. Verify that the voltage and current waveforms are being properly measured on the Odyssey data recorder channels 3,11, and 19.	
33	Close AFCB-4, turn on using the cockpit switch and verify via visual means that the PASSENGER CEILING LIGHTS – LEFT SIDE are operating. Verify that the voltage and current waveforms are being properly measured on the Odyssey data recorder channels 4, 12, and 20.	
34	Close AFCB-5, turn on using the cockpit switch and verify via visual means that the DME is operating. Verify that the voltage and current waveforms are being properly measured on the Odyssey data recorder channels 5, 13, and 21.	
35	Close AFCB-6, turn on using the cockpit switch and verify via the Pitot Ammeter that the HEATER-PITOT-AUX is operating. Verify that the voltage and current waveforms are being properly measured on the Odyssey data recorder channels 6, 14, and 22.	
36	Close AFCB-7, turn on using the cockpit switch and verify by via visual means that the FIRST OFFICER'S WINDOW HEATER is operating. Verify that the voltage and current waveforms are being properly measured on the Odyssey data recorder channels 7, 15, and 23.	
37	Close AFCB-8, turn on using the cockpit switch and verify that PROJECT POWER is operating. Verify that the voltage and current waveforms are being properly measured on the Odyssey data recorder channels 8, 16 and 24.	
38	Open and close the Left Inboard Landing Lights aircraft circuit breaker five times. Verify that AFCB-1 did not nuisance trip during the five open-close cycles.	
39	Open and close the Navigation Lights aircraft circuit breaker five times. Verify that AFCB-2 did not nuisance trip during the five open-close	

	cycles.	
40	Open and close the Window Lights aircraft circuit breaker five times. Verify that AFCB-3 did not nuisance trip during the five open-close cycles.	
41	Open and close the Left Ceiling Lights aircraft circuit breaker five times. Verify that AFCB-4 did not nuisance trip during the five open-close cycles.	
42	Open and close the DME-2 aircraft circuit breaker five times. Verify that AFCB-5 did not nuisance trip during the five open-close cycles.	
43	Open and close the Auxiliary Pitot Heat aircraft circuit breaker five times. Verify that AFCB-6 did not nuisance trip during the five open-close cycles.	
44	Open and close the First Officers Window aircraft circuit breaker five times. Verify that AFCB-7 did not nuisance trip during the five open-close cycles.	
45	Open and close the AC Project Power aircraft circuit breaker five times. Verify that AFCB-8 did not nuisance trip during the five open-close cycles.	
46	With the eight aircraft circuit breakers and the eight AFCBs closed switch from ground power to APU power. Verify that no nuisance trips occurred. Switch from APU power to engine power. Verify that no nuisance trips occurred. Reverse this process and verify that no nuisance trips occurred after each step. Repeat this cycle four additional times.	
47	With aircraft electrical power on (ground, APU, or engine) and the aircraft circuit breakers closed, begin recording on the Odyssey by pressing the record button. Open AFCB-1. The trigger alarm shall activate. Close AFCB-1 and reset the trigger alarm. Repeat this process for AFCB-2 through AFCB-8.	
48	Turn on RADAR, IFF, RADAR Altimeter, and all Radios	
49	With aircraft electrical power on (ground, APU, or engine) and the aircraft circuit breakers and AFCBs closed, test aircraft systems in accordance with the B727 Standard Start-up checklist. An Odyssey data recording shall be made as each load is tested. For voice communication, conduct	

	transmission checks on each radio. No AFCBs shall nuisance trip during these tests. Confirm that the AFCBs and instrumentation do not interfere with the operation of the aircraft system.	
50	Save all instrumentation recordings and download to removable disc.	
51	Turn off instrumentation equipment	
52	Set AFCI-JB S1 thru AFCI-JB S8 to BYPASS	
53	Open AFCB-1 through AFCB-8	
54	Shut down Aircraft Power IAW standard operating procedures	

- - End of AFCB Electrical Tests - -

Electrical Tests completed by _____ Verified by _____
Name and Date Name and Date

APPENDIX C – TIME DOMAIN REFLECTOMETRY BASELINE TEST PROCEDURES / VERIFICATION SHEET

Conduct Time Domain Reflectometry Baseline Tests

The eight AFCB test circuits will be characterized using a Time Domain Reflectometry (TDR) technique. The purpose of this test is to baseline the existing condition of each circuit to be used as a reference benchmark. If an AFCB should trip during flight test, a new TDR measurement of the effected circuit will be conducted and compared to the original benchmark. This will assist in determining the presence and location of the fault. The TDR testing will be conducted by CM Technologies under the supervision of John Beres.

TDR Tools and Equipment:

The tools and equipment listed below shall be supplied by CM Technologies.

- Electrical Characterization and Diagnostics ($ECAD_{TM}$) System 1100. The $ECAD_{TM}$ system injects a pulse of 1V amplitude, and 400μsec pulse width. In the worst case, the maximum energy of the pulse is 8μJ. The pulse applied in the Excited Dielectric Test (EDT), described below, is even lower. The pulse amplitude is only 200 mV and the pulse width is narrower than the 400μsec pulse used in the standard TDR test.
- Agilent 86100A Oscilloscope Mainframe with 54754A Time Domain Reflectometer Plug-in Module.
- Tabor 8020 Function Generator.
- Coupling network, test lead cables, and clips.

TDR Precautions

The ECADTM System 1100 is designed to test de-energized wires. Computer logic first checks the circuit for AC and DC voltage and will not permit an automatic test if a significant voltage level is found (greater than 5 VDC or VAC). Attempting to test energized wiring may damage the ECAD instrumentation and/or represent a safety hazard to test personnel.

TDR Test Supervision

The WJHTC Electrical Systems DER is responsible for managing the arc fault circuit breaker installation and testing aboard N40. The CM Technologies field engineer shall discuss the test plan with the Electrical Systems DER to ensure compliance with all applicable FAA quality and/or testing procedures.

- ❑ The WJHTC Electrical Systems DER (or designee) shall be responsible for opening any panels to gain access to breakers, opening breakers to de-energize circuits, and restoring the circuits to an operational (pre-test) condition.

TDR Procedure

ECAD$_{TM}$ System 1100 Equipment Setup:

- ❑ Locate the ECAD$_{TM}$ System 1100 near the circuits to be tested. Ideally, the equipment will be located within 10 to 25 feet from the test location.
- ❑ Provide the equipment with a source of 120 VAC, 60 Hz power.
- ❑ Connect power, signal, and test leads to the equipment as required.
- ❑ Turn on the ECAD$_{TM}$ System 1100 and start the data acquisition software.
- ❑ Load the AFCB database files.
- ❑ Execute the system self-test. The self-test checks the proper operation of each instrument card and measures the electrical properties associated with the test lead.

ECAD$_{TM}$ Testing:

- ❑ Select the device/circuit to be tested from the ECAD AFCB database.
- ❑ Verify the circuit to be tested matches the circuit descriptive data (CDD) displayed in the ECAD$_{TM}$ software. Also, verify the circuit to be tested is de-energized.
- ❑ Connect the ECAD$_{TM}$ test clips to the circuit as indicated in the HIGH TEST PT and LOW TEST PT fields of the CDD screen.
- ❑ Using a digital multi-meter, measure resistance from the conductor to aircraft ground. If resistance is less than 500kΩ stop the test and troubleshoot the circuit wiring. If greater than 500kΩ, proceed to next step.
- ❑ The Insulation Resistance (IR) TEST VOLTS field of the CDD screen indicates the MAXIMUM IR test voltage that is allowed. The maximum applied voltage will be 50VDC. Testing at voltages greater than this value could damage circuit components. A value of zero (0) volts in this field indicates that an IR test is not to be performed for this configuration.
- ❑ Initiate a TEST of the selected configuration.
- ❑ Review the measurement data as required.
- ❑ Repeat ECAD Testing steps until all of the eight circuits have been characterized.

Excited Dielectric Test (EDT) Equipment Setup:

- ❑ Locate the EDT test equipment near the circuits to be tested. Ideally, the equipment will be located within 10 to 25 feet from the test location.
- ❑ Provide the equipment with a source of 120 VAC, 60 Hz power.

- ❑ Connect power, signal, and test leads to the equipment as required.
- ❑ Turn on the Agilent 86100A.

EDT Testing:

- ❑ Connect the alligator test clips to the same test locations that were used during the ECAD testing.
- ❑ Acquire three (3) TDR signatures using three (3) forcing function frequencies. The three frequencies will be determined from the insulation materials used in the circuit under test.
- ❑ Waveforms will be named and saved for storage in the Agilent 86100A.
- ❑ Review the TDR waveform as required.
- ❑ Repeat EDT Testing steps until all of the test configurations have been completed.

Circuit Restoration:

- ❑ Disconnect all test clips.
- ❑ Restore the circuit to normal as directed by the Electrical Systems DER.
- ❑ Perform functional test on the restored circuit, if needed.

- - End of Time Domain Reflectometry Baseline Tests - -

Attach test results to this verification sheet.

TDR Tests completed by _____ Verified by _____

Name and Date Name and Date

APPENDIX H—HENDRY FLIGHT TEST RECORDS

Hendry Flight Test Records

HENDRY FLIGHT TEST HOURS									
								Circuit Breaker Hours	
Flight	Date	From	To	In Service Time	Block Time	Cumulative In Service	Cumulative Block	Block Time	Cumulative Block
1	8/5/02	KACY	local	1.2	1.6	1.2	1.6	12.8	12.8
2	8/6/02	KACY	KSYR	2.2	2.3	3.4	3.9	18.4	31.2
3	8/6/02	KSYR	KACY	0.9	1.3	4.3	5.2	10.4	41.6
4	8/15/02	KACY	KGTF	4.3	4.5	8.6	9.7	36.0	77.6
5	8/15/02	KGTF	KBFI	1.4	1.7	10.0	11.4	13.6	91.2
6	8/16/02	KBFI	KACY	4.2	4.5	14.2	15.9	36.0	127.2
7	8/19/02	KACY	KGTF	4.4	4.5	18.6	20.4	36.0	163.2
8	8/19/02	KGTF	KANC	3.8	4.2	22.4	24.6	33.6	196.8
9	8/20/02	KANC	local	0.1	0.4	22.5	25.0	3.2	200.0
10	8/23/02	KACY	local	1.9	2.1	24.4	27.1	16.8	216.8
11	9/23/02	KACY	KMIA	2.3	2.5	26.7	29.6	20.0	236.8
12	9/24/02	KMIA	TSJ	2.3	2.5	29.0	32.1	20.0	256.8
13	9/24/02	TSJ	KMIA	2.4	2.6	31.4	34.7	20.8	277.6
14	9/25/02	KMIA	KMIA	3.1	3.5	34.5	38.2	25.5	303.1
15	9/26/02	KMIA	KMIA	2.4	2.6	36.9	40.8	20.8	323.9
16	9/26/02	KMIA	KACY	2.1	2.5	39.0	43.3	20.0	343.9
17	9/30/02	KACY	KGTF	4.1	4.3	43.1	47.6	34.4	378.3
19	9/30/02	KGTF	KBFI	1.3	1.5	44.4	49.1	12.0	390.3
20	9/30/02	KBFI	KBFI	2.3	2.6	46.7	51.7	20.8	411.1
21	10/1/02	KBFI	KBFI	2.4	2.8	49.1	54.5	22.4	433.5
22	10/1/02	KBFI	KBFI	2.3	2.5	51.4	57.0	20.0	453.5
23	10/2/02	KBFI	KBFI	2.3	2.6	53.7	59.6	20.8	474.3
24	10/3/02	KBFI	KGRB	3.1	3.3	56.8	62.9	26.4	500.7
25	10/3/02	KGRB	KGRB	2.6	3.1	59.4	66.0	24.8	525.5
26	10/4/02	KGRB	KACY	1.7	2.2	61.1	68.2	17.6	543.1
27	10/6/02	KACY	KGRB	1.8	2.0	62.9	70.2	16.0	559.1
29	10/6/02	KGRB	KGRB	2.1	2.3	65.0	72.5	18.4	577.5
30	10/7/02	KGRB	KGRB	1.6	1.8	66.6	74.3	14.4	591.9
31	10/8/02	KGRB	KGTF	2.5	2.7	69.1	77.0	21.6	613.5
32	10/8/02	KGTF	KGTF	1.6	1.8	70.7	78.8	14.4	627.9
33	10/9/02	KGTF	KGTF	1.6	1.9	72.3	80.7	15.2	643.1
34	10/9/02	KGTF	KGTF	1.6	1.7	73.9	82.4	13.6	656.7
35	10/10/02	KGTF	KGTF	1.5	1.8	75.4	84.2	14.4	671.1
36	10/11/02	KGTF	KACY	3.6	3.8	79.0	88.0	30.4	701.5

FAA AIRCRAFT REQUEST AND USE RECORD

(Use of FAA aircraft must be in compliance with Order 4040.9 series)

AIRCRAFT REQUEST

1. Source of Aircraft	2. Type Aircraft Desired	2a Type of Flight	3. Date Required
☒ FAA ☐ Rental ☐ Out of Agency Crew Data Only	B-727	☒ FAR 91 ☐ FAR 135 ☐ FAR 125 ☐ Public	8/5/02

4. Justification. *(Explain why Agency/Rental Aircraft is being used. Show proposed itinerary, names/number of passengers and crew, estimated flight hours, and rental cost.)*

DATA COLLECTION AND SYSTEM EVALUATION IN ACCORDANCE WITH APPROVED FLIGHT TEST PLAN AND APPROVED WEEKLY FLIGHT SCHEDULE

Approval Required Before Flight	Signature	Printed Name	Rtg Symbol	Date
5. Requested By:				
6. Approved By:				
6a. Chief or Regional Counsel Approval: *(when required)*				

7. Type Aircraft Used	8. Acft. Code or Rental Category	9. Registration (N) Number	10. Activity	11. User Organization	12. Reimbursement Account
B727	33	N40	T	RDFP	T-1708481

13. Purpose of Flight *(AMIS code)*

☐ 01. Evaluation ☐ 02. Currency ☐ 03. Transportation ☐ 04. Check Flight ☐ 05. Logistics ☒ 06. R&D ☐ 07. Formal Training ☐ 08. Proficiency Q&S ☐ 09. Reimbursable ☐ 10. Test & Ferry ☐ 11. FS Itinerary ☐ 12. Accident Investigation ☐ 13. Certification Testing ☐ 14. Military ☐ 15. Observation Flight ☐ 16. Other

14. Itinerary

Date	From	To	Block Out	Time in Service Takeoff	Time in Service Landing	Block In	Time in Svc.	Block to Block
a.	b.	c.	d.	e.	f.	g.	h.	i.
8/5/02	KACY	KACY	1330	5057.6	5058.8	1505	1.2	1.6
j. Total Time in Service *(Takeoff to landing)* ⇒							1.2	
k. Total Flight Time *(Block to Block)* ⇒								1.6

15. Passengers

Full Name of Passenger(s) *(Continue on reverse or attach list)*	RTG Symbol or Agency	From	To
a. List or attach emergency contacts.	b.	c.	d.
PAPPAS, R.	NAR-433	KACY	KACY
⇐ 15e. Total No. of Passengers			

16. Crew Data — Flight Time *(Enter Flight Times in Hours and 1/10)*

a. Crew Identification Name	a1. Crew #	b. PIC HRS	b. PIC 1/10	c. SIC HRS	c. SIC 1/10	d. Pilot HRS	d. Pilot 1/10	e. IP HRS	e. IP 1/10	f. FE HRS	f. FE 1/10	g. Other 1/10	h. Hood HRS	h. Hood 1/10	i. Wthr. HRS	i. Wthr. 1/10	j. Night HRS	j. Night 1/10	k. Takeoffs D	k. Takeoffs N	l. Lndgs. D	l. Lndgs. N	m. Hold	n. Apprchs P	n. Apprchs N
BIEHL	CT-006	0	8	0	8	0	8												3		3			3	
KARL	CT-012	0	8	0	8	0	8												3		3			3	
TATHAM	CT-024									1	6														

17. Rental Aircraft Data

17a. Method of Payment

☐ Contract or BPA rental time
Contract #_____
☐ IMPAC Credit Card
☐ SF44
☐ 3rd Party Check
☐ Purchase Order
PO # _____

17b. Charges

A. Total Rental Time, Hrs. / Tenths _____
B. Cost / Hr $_____
C. Rental Cost (A x B) = $_____
D. Other Cost $_____
E. Total Cost $_____

17c. Aircraft Rented From *(Name, Address, and Phone)*

18. Fuel

Gallons	Cost	Type:	How Purchased:
1940		( ) AVGAS (X) JET	( ) C - Commercial ( ) D - Contract ( ) M - Military ( ) W - Wet

19. OFFICE USE ONLY Verified By	INITIALS	DATE
20. DATABANK ENTRY Verified By	INITIALS	DATE

FAA Form 4040-8 (12/97) (NSN 0052-00-665-0003) Supersedes previous edition

AFTER FLIGHT: Return to Approving Office Without Delay

FAA AIRCRAFT REQUEST AND USE RECORD

(Use of FAA aircraft must be in compliance with Order 4040.9 series)

AIRCRAFT REQUEST

1. Source of Aircraft	2. Type Aircraft Desired	2a Type of Flight	3. Date Required
☒ FAA ☐ Rental ☐ Out of Agency Crew Data Only	B727	☒ FAR 91 ☐ FAR 135 ☐ FAR 125 ☐ Public	8/6/02

4. Justification. *(Explain why Agency/Rental Aircraft is being used. Show proposed itinerary, names/number of passengers and crew, estimated flight hours, and rental cost.)*

DATA COLLECTION AND SYSTEM EVALUATION IN ACCORDANCE WITH APPROVED FLIGHT TEST PLAN AND APPROVED WEEKLY FLIGHT SCHEDULE

Approval Required Before Flight	Signature	Printed Name	Rtg Symbol	*Date*
5. Requested By:				
6. Approved By:				
6a. Chief or Regional Counsel Approval: *(when required)*				

7. Type Aircraft Used	8. Acft. Code or Rental Category	9. Registration (N) Number	10. Activity	11. User Organization	12. Reimbursement Account
B 727	33	N4D	T	RDFP	T-1708481

13. Purpose of Flight *(AMIS code)*

☐ 01. Evaluation ☐ 02. Currency ☐ 03. Transportation ☐ 04. Check Flight ☐ 05. Logistics ☒ 06. R&D ☐ 07. Formal Training ☐ 08. Proficiency Q&S ☐ 09. Reimbursable ☐ 10. Test & Ferry ☐ 11. FS Itinerary ☐ 12. Accident Investigation ☐ 13. Certification Testing ☐ 14. Military ☐ 15. Observation Flight ☐ 16. Other

14. Itinerary

Date	From	To	Block Out	Time in Service Takeoff	Time in Service Landing	Block In	Time in Svc.	Block to Block
a.	b.	c.	d.	e.	f.	g.	h.	i.
8/6/02	KACY	KSYR	0930	5058.8	5061.0	1245	2.2	3.3
8/6/02	KSYR	KACY	1435	5061.0	5061.9	1550	0.9	1.3
j. Total Time in Service *(Takeoff to landing)* ⇒							3.1	
k. Total Flight Time *(Block to Block)* ⇒								4.6

15. Passengers

Full Name of Passenger(s) *(Continue on reverse or attach list)*	RTG Symbol or Agency	From	To
a. List or attach emergency contacts.	b.	c.	d.
R. PAPPAS	AAR-443	KACY	KACY
J. RANDAZZO	ACB-520	—	—
M. MC CANN	—	—	—
D. DELLMYER	—	—	—

FAA AIRCRAFT REQUEST AND USE RECORD

(Use of FAA aircraft must be in compliance with Order 4040.9 series)

AIRCRAFT REQUEST

1. Source of Aircraft: [X] FAA [ ] Rental [ ] Out of Agency Crew Data Only
2. Type Aircraft Desired: B-727
2a. Type of Flight: [X] FAR 91 [ ] FAR 135 [ ] FAR 125 [ ] Public
3. Date Required: 8/15/2002

4. Justification. *(Explain why Agency/Rental Aircraft is being used. Show proposed itinerary, names/number of passengers and crew, estimated flight hours, and rental cost.)*

DATA COLLECTION AND SYSTEM EVALUATION IN ACCORDANCE WITH APPROVED FLIGHT TEST PLAN AND APPROVED WEEKLY FLIGHT SCHEDULE

Approval Required Before Flight	Signature	Printed Name	Rtg Symbol	Dat
5. Requested By:				
6. Approved By:				
6a. Chief or Regional Counsel Approval: *(when required)*				

7. Type Aircraft Used	8. Acft. Code or Rental Category	9. Registration (N) Number	10. Activity	11. User Organization	12. Reimbursement Account
B-727	33	40	T	RDFP	T1708481

13. Purpose of Flight *(AMIS code)*
[ ] 01. Evaluation [ ] 02. Currency [ ] 03. Transportation [ ] 04. Check Flight [ ] 05. Logistics [X] 06. R&D [ ] 07. Formal Training [ ] 08. Proficiency O&S [ ] 09. Reimbursable [ ] 10. Test & Ferry [ ] 11. FS Itinerary [ ] 12. Accident Investigation [ ] 13. Certification Testing [ ] 14. Military [ ] 15. Observation Flight [ ] 16. Other

14. Itinerary

Date	From	To	Block Out	Time in Service Takeoff	Time in Service Landing	Block In	Time in Svc.	Block to Block
a.	b.	c.	d.	e.	f.	g.	h.	i.
8/15/02	ACY	ACY	0830	5061.9	5062.1	0900	.2	.5
	ACY	GTF	1000	5062.1	5066.4	1430	4.3	4.5
↓	GTF	BFI	1520	5066.4	5067.8	1700	1.4	1.7
j. Total Time in Service *(Takeoff to landing)* ⇒							5.9	
k. Total Flight Time *(Block to Block)* ⇒								6.7

15. ~~Passengers~~ PROJECT CREW

Full Name of Passenger(s) *(Continue on reverse or attach list)*	RTG Symbol or Agency	From	To
a. List or attach emergency contacts	b.	c.	d.
R			

⇐ 15e. Total No. of Passengers

16. Crew Data — Flight Time *(Enter Flight Times in Hours and 1/10)*

a. Crew Identification Name	a1. Crew #	b. PIC HRS	b. PIC 1/10	c. SIC HRS	c. SIC 1/10	d. Pilot HRS	d. Pilot 1/10	e. IP HRS	e. IP 1/10	f. FE HRS	f. FE 1/10	g. Other HRS	g. Other 1/10	h. Hood HRS	h. Hood 1/10	i. Wthr. HRS	i. Wthr. 1/10	j. Night HRS	j. Night 1/10	k. Takeoffs D	k. Takeoffs N	l. Lndgs. D	l. Lndgs. N	m. Hold	n. Approchs P	n. Approchs N
VANHOY, L	CT007	6	7			4	8										6			3		3				
FABER, L	CT009			6	7	1	9										6			2		2				
TAYLOR, J	CT024									6	7															
BIRNEY J	CT021											6	7													

17. Rental Aircraft Data

17a. Method of Payment
[ ] Contract or BPA rental time — Contract # _____
[ ] IMPAC Credit Card
[ ] SF44
[ ] 3rd Party Check
[ ] Purchase Order
PO # _____

17b. Charges
A. Total Rental Time, Hrs. / Tenths _____
B. Cost / Hr $ _____
C. Rental Cost (A x B) = $ _____
D. Other Cost $ _____
E. Total Cost $ _____

17c. Aircraft Rented From *(Name, Address, and Phone)*

18. Fuel

Gallons	Cost	Type:	How Purchased:
600		( ) AVGAS	( ) C - Commercial ( ) D - Contract
4836		( ) JET	( ) M - Military ( ) W - Wet
7350			

7400 GAL

18. OFFICE USE ONLY Verified By — INITIALS — DATE

20. DATABANK ENTRY Verified By — INITIALS — DATE

FAA Form 4040-6 (12/97) (NSN 0052-00-865-0003) Supersedes previous edition

AFTER FLIGHT: Return to Approving Office Without Delay

FAA AIRCRAFT REQUEST AND USE RECORD

(Use of FAA aircraft must be in compliance with Order 4040.9 series)

AIRCRAFT REQUEST

1. Source of Aircraft: [X] FAA [ ] Rental [ ] Out of Agency Crew Data Only
2. Type Aircraft Desired: B-727
2a. Type of Flight: [X] FAR 91 [ ] FAR 135 [ ] FAR 125 [ ] Public
3. Date Required: 8/16/2002

4. Justification. *(Explain why Agency/Rental Aircraft is being used. Show proposed itinerary, names/number of passengers and crew, estimated flight hours, and rental cost.)*

DATA COLLECTION AND SYSTEM EVALUATION IN ACCORDANCE WITH APPROVED FLIGHT TEST PLAN AND APPROVED WEEKLY FLIGHT SCHEDULE

Approval Required Before Flight	Signature	Printed Name	Rtg Symbol	Date
5. Requested By:				
6. Approved By:				
6a. Chief or Regional Counsel Approval: *(when required)*				

7. Type Aircraft Used	8. Acft. Code or Rental Category	9. Registration (N) Number	10. Activity	11. User Organization	12. Reimbursement Account
B-727	33	40	T	RDFP	T1708481

13. Purpose of Flight *(AMIS code)*

- [ ] 01. Evaluation
- [ ] 02. Currency
- [ ] 03. Transportation
- [ ] 04. Check Flight
- [ ] 05. Logistics
- [X] 06. R&D
- [ ] 07. Formal Training
- [ ] 08. Proficiency Q&S
- [ ] 09. Reimbursable
- [ ] 10. Test & Ferry
- [ ] 11. FS Itinerary
- [ ] 12. Accident Investigation
- [ ] 13. Certification Testing
- [ ] 14. Military
- [ ] 15. Observation Flight
- [ ] 16. Other

14. Itinerary

Date	From	To	Block Out	Time in Service Takeoff	Time in Service Landing	Block in	Time in Svc.	Block to Block
a.	b.	c.	d.	e.	f.	g.	h.	i.
~~8/14/02~~	~~BFI~~							
8/16/02	BFI	ACY	0700	5067.8	5072.0	1130	4.2	4.5
j. Total Time in Service *(Takeoff to landing)* ⇒							4.2	
k. Total Flight Time *(Block to Block)* ⇒								4.5

15. ~~Passengers~~ PROJECT CREW

Full Name of Passenger(s) *(Continue on reverse or attach list)*	RTG Symbol or Agency	From	To
a. List or attach emergency contacts.	b.	c.	d.
R			

FAA AIRCRAFT REQUEST AND USE RECORD

(Use of FAA aircraft must be in compliance with Order 4040.9 series)

AIRCRAFT REQUEST

1. Source of Aircraft	2. Type Aircraft Desired	2a. Type of Flight	3. Date Required
☒ FAA ☐ Rental ☐ Out of Agency Crew Data Only	B-727	☒ FAR 91 ☐ FAR 135 ☐ FAR 125 ☐ Public	8/19/2002

4. Justification. *(Explain why Agency/Rental Aircraft is being used. Show proposed itinerary, names/number of passengers and crew, estimated flight hours, and rental cost.)*

DATA COLLECTION AND SYSTEM
EVALUATION IN ACCORDANCE WITH
APPROVED FLIGHT TEST PLAN AND
APPROVED WEEKLY FLIGHT SCHEDULE

Approval Required Before Flight	Signature	Printed Name	Rtg Symbol	Date
5. Requested By:				
6. Approved By:				
6a. Chief or Regional Counsel Approval: *(when required)*				

7. Type Aircraft Used	8. Acft. Code or Rental Category	9. Registration (N) Number	10. Activity	11. User Organization	12. Reimbursement Account
B-727	33	HO	T	RDFP	T1708481

13. Purpose of Flight *(AMIS code)*

☐ 01. Evaluation	☐ 05. Logistics	☐ 09. Reimbursable	☐ 13. Certification Testing
☐ 02. Currency	☒ 06. R&D	☐ 10. Test & Ferry	☐ 14. Military
☐ 03. Transportation	☐ 07. Formal Training	☐ 11. FS Itinerary	☐ 15. Observation Flight
☐ 04. Check Flight	☐ 08. Proficiency Q&S	☐ 12. Accident Investigation	☐ 16. Other

14. Itinerary

Date	From	To	Block Out	Time in Service Takeoff	Time in Service Landing	Block In	Time in Svc.	Block to Block
a.	b.	c.	d.	e.	f.	g.	h.	i.
8/19/02	ADY	GTF	0915	5072.0	5076.4	1345	4.4	4.5
	GTF	ANC	1415	5076.4	5080.2	1855	3.8	4.2
j. Total Time in Service *(Takeoff to landing)* ⇒							8.2	
k. Total Flight Time *(Block to Block)* ⇒								8.7

15. Passengers

Full Name of Passenger(s) *(Continue on reverse or attach list)*	RTG Symbol or Agency	From	To
a. List or attach emergency contacts.	b.	c.	d.
⇐ - 15e. Total No. of Passengers			

16. Crew Data — Flight Time *(Enter Flight Times in Hours and 1/10)*

a. Crew Identification Name	a1. Crew #	b. PIC HRS	b. PIC 1/10	c. SIC HRS	c. SIC 1/10	d. Pilot HRS	d. Pilot 1/10	e. IP HRS	e. IP 1/10	f. FE HRS	f. FE 1/10	g. Other HRS	g. Other 1/10	h. Hood HRS	h. Hood 1/10	i. Wthr. HRS	i. Wthr. 1/10	j. Night HRS	j. Night 1/10	k. Takeoffs D	k. Takeoffs N	l. Lndgs. D	l. Lndgs. N	m. Hold	n. Approchs P	n. Approchs N
VAN HOY	CTOC7	4	5	4	2	4	5									1	5									
EHRHART	CTO14	4	2	4	5	4	2									1	5			1		1			1	
TATHAM	CTO24									8	7															
BIRNEY	CTO21											8	7													

17. Rental Aircraft Data

17a. Method of Payment

☐ Contract or BPA rental time
Contract #_____

☐ IMPAC Credit Card

☐ SF44

☐ 3rd Party Check

☐ Purchase Order

PO # _____

17b. Charges

A. Total Rental Time, Hrs. / Tenths _____.____

B. Cost / Hr $_____.____

C. Rental Cost (A x B) = $_____.____

D. Other Cost $_____.____

E. Total Cost $_____.____

17c. Aircraft Rented From *(Name, Address, and Phone)*

18. Fuel

Gallons	Cost	Type:	How Purchased:
10,887		( ) AVGAS ( ) JET	( ) C - Commercial ( ) D - Contract ( ) M - Military ( ) W - Wet

19. OFFICE USE ONLY Verified By	
INITIALS	DATE
20. DATABANK ENTRY Verified By	
INITIALS	DATE

FAA Form 4040-9 (12/97) (NSN 0052-00-865-0003) Supersedes previous edition

AFTER FLIGHT: Return to Approving Office Without Delay

FAA AIRCRAFT REQUEST AND USE RECORD

(Use of FAA aircraft must be in compliance with Order 4040.9 series)

AIRCRAFT REQUEST

1. Source of Aircraft: [X] FAA [ ] Rental [ ] Out of Agency Crew Data Only
2. Type Aircraft Desired: B-727
2.a Type of Flight: [X] FAR 91 [ ] FAR 135 [ ] FAR 125 [ ] Public
3. Date Required: 8/20/2002

4. Justification. *(Explain why Agency/Rental Aircraft is being used. Show proposed itinerary, names/number of passengers and crew, estimated flight hours, and rental cost.)*

DATA COLLECTION AND SYSTEM EVALUATION IN ACCORDANCE WITH APPROVED FLIGHT TEST PLAN AND APPROVED WEEKLY FLIGHT SCHEDULE

Approval Required Before Flight	Signature	Printed Name	Rtg Symbol	Date
5. Requested By:				
6. Approved By:				
6a. Chief or Regional Counsel Approval: *(when required)*				

7. Type Aircraft Used	8. Acft. Code or Rental Category	9. Registration (N) Number	10. Activity	11. User Organization	12. Reimbursement Account
B-727	33	40	T	RDFP	T1708481

13. Purpose of Flight *(AMIS code)*

[ ] 01. Evaluation [ ] 02. Currency [ ] 03. Transportation [ ] 04. Check Flight [ ] 05. Logistics [X] 06. R&D [ ] 07. Formal Training [ ] 08. Proficiency Q&S [ ] 09. Reimbursable [ ] 10. Test & Ferry [ ] 11. FS Itinerary [ ] 12. Accident Investigation [ ] 13. Certification Testing [ ] 14. Military [ ] 15. Observation Flight [ ] 16. Other

14. Itinerary

Date	From	To	Block Out	Time in Service Takeoff	Time in Service Landing	Block In	Time in Svc.	Block to Block
a.	b.	c.	d.	e.	f.	g.	h.	i.
8/20/02	ANC	ANC	1350	5080.2	5080.3	1415	.1	.4
	ANC							
j. Total Time in Service *(Takeoff to landing)* ⇒							.1	
k. Total Flight Time *(Block to Block)* ⇒								.4

15. Passengers

Full Name of Passenger(s) *(Continue on reverse or attach list)*	RTG Symbol or Agency	From	To
a. List or attach emergency contacts.	b.	c.	d.
⊂ - 15e. Total No. of Passengers			

16. Crew Data — Flight Time *(Enter Flight Times in Hours and 1/10)*

a. Crew Identification Name	a1. Crew #	b. PIC HRS	b. PIC 1/10	c. SIC HRS	c. SIC 1/10	d. Pilot HRS	d. Pilot 1/10	e. IP HRS	e. IP 1/10	f. FE HRS	f. FE 1/10	g. Other HRS	g. Other 1/10	h. Hood HRS	h. Hood 1/10	i. Wthr. HRS	i. Wthr. 1/10	j. Night HRS	j. Night 1/10	k. Takeoffs D	k. Takeoffs N	l. Lndgs. D	l. Lndgs. N	m. Hold	n. Apprchs P	n. Apprchs N
VAN HOY, L	CT007		4				4										1			1		1			1	
EHRHART, M	CT014				4												1									
TATHAM, T	CT024										4															

17. Rental Aircraft Data

17a. Method of Payment

[ ] Contract or BPA rental time
Contract # _____
[ ] IMPAC Credit Card
[ ] SF44
[ ] 3rd Party Check
[ ] Purchase Order
PO # _____

17b. Charges

A. Total Rental Time, Hrs. / Tenths _____
B. Cost / Hr $_____
C. Rental Cost (A x B) = $_____
D. Other Cost $_____
E. Total Cost $_____

17c. Aircraft Rented From *(Name, Address, and Phone)*

18. Fuel: Gallons 415 | Cost | Type: ( ) AVGAS ( ) JET | How Purchased: ( ) C - Commercial ( ) D - Contract ( ) M - Military ( ) W - Wet

18. OFFICE USE ONLY Verified By — INITIALS — DATE

20. DATABANK ENTRY Verified By — INITIALS — DATE

FAA Form 4040-6 (12/97) (NSN 0052-00-865-0003) Supersedes previous edition

AFTER FLIGHT: Return to Approving Office Without Delay

FAA AIRCRAFT REQUEST AND USE RECORD

(Use of FAA aircraft must be in compliance with Order 4040.9 series)

AIRCRAFT REQUEST

1. Source of Aircraft	2. Type Aircraft Desired	2.a Type of Flight	3. Date Required
☒ FAA ☐ Rental ☐ Out of Agency Crew Data Only	B-727	☒ FAR 91 ☐ FAR 135 ☐ FAR 125 ☐ Public	8/23/02

4. Justification. *(Explain why Agency/Rental Aircraft is being used. Show proposed itinerary, names/number of passengers and crew, estimated flight hours, and rental cost.)*

DATA COLLECTION AND SYSTEM
EVALUATION IN ACCORDANCE WITH
APPROVED FLIGHT TEST PLAN AND
APPROVED WEEKLY FLIGHT SCHEDULE

Approval Required Before Flight	Signature	Printed Name	Rtg Symbol	*Date*
5. Requested By:				
6. Approved By:				
6a. Chief or Regional Counsel Approval: *(when required)*				

7. Type Aircraft Used	8. Acft. Code or Rental Category	9. Registration (N) Number	10. Activity	11. User Organization	12. Reimbursement Account
B-727	33	40	T	RDFP	T170848I

13. Purpose of Flight *(AMIS code)*

☐ 01. Evaluation ☐ 02. Currency ☐ 03. Transportation ☐ 04. Check Flight ☐ 05. Logistics ☒ 06. R&D ☐ 07. Formal Training ☐ 08. Proficiency Q&S ☐ 09. Reimbursable ☐ 10. Test & Ferry ☐ 11. FS Itinerary ☐ 12. Accident Investigation ☐ 13. Certification Testing ☐ 14. Military ☐ 15. Observation Flight ☐ 16. Other

14. Itinerary

Date	From	To	Block Out	Time in Service Takeoff	Time in Service Landing	Block in	Time in Svc.	Block to Block
a.	b.	c.	d.	e.	f.	g.	h.	i.
8/23/02	ACY	ACY	1320	5087.3	5089.2	1525	1.9	2.1
j. Total Time in Service *(Takeoff to landing)* ⇒							1.9	
k. Total Flight Time *(Block to Block)* ⇒								2.1

15. Passengers

Full Name of Passenger(s) *(Continue on reverse or attach list)*	RTG Symbol or Agency	From	To
a. List or attach emergency contacts.	b.	c.	d.
⇐ - 15e. Total No. of Passengers			

16. Crew Data — Flight Time *(Enter Flight Times in Hours and 1/10)*

a. Crew Identification Name	a1. Crew #	b. PIC HRS	b. PIC 1/10	c. SIC HRS	c. SIC 1/10	d. Pilot HRS	d. Pilot 1/10	e. IP HRS	e. IP 1/10	f. FE HRS	f. FE 1/10	g. Other HRS	g. Other 1/10	h. Hood HRS	h. Hood 1/10	i. Wthr. HRS	i. Wthr. 1/10	j. Night HRS	j. Night 1/10	k. Takeoffs D	k. Takeoffs N	l. Lndgs. D	l. Lndgs. N	m. Hold	n. Apprchs P	n. Apprchs N
VANHOY	CT007	2	1														5									
FABER	CT009			2	1	2	1										5			1		1			1	
TAYLOR	CT024									2	1															

17. Rental Aircraft Data

17a. Method of Payment

☐ Contract or BPA rental time
Contract # _____
☐ IMPAC Credit Card
☐ SF44
☐ 3rd Party Check
☐ Purchase Order
PO # _____

17b. Charges

A. Total Rental Time, Hrs. / Tenths _____
B. Cost / Hr $_____
C. Rental Cost (A x B) = $_____
D. Other Cost $_____
E. Total Cost $_____

17c. Aircraft Rented From *(Name, Address, and Phone)*

18. Fuel

Gallons	Cost	Type:	How Purchased:
4500		( ) AVGAS ( ) JET	( ) C - Commercial ( ) D - Contract ( ) M - Military ( ) W - Wet

18. OFFICE USE ONLY Verified By — INITIALS — DATE

20. DATABANK ENTRY Verified By — INITIALS — DATE

FAA Form 4040-6 (12/97) (NSN 0052-00-865-0003) Supersedes previous edition

AFTER FLIGHT: Return to Approving Office Without Delay

(Use of FAA aircraft must be in compliance with Order 4040.# as amended)

Aircraft / Simulator Request and Approval Data

1. Source of Aircraft	2. Aircraft Type Desired	3. Date(s) Required	4. Type of Flight	5. Passenger Information
☒ FAA ☐ Rental	B727	Fm: 9/23/02 To: ___/___/___	FAR 91	Reportable to GSA ☐ Yes ☐ No Space Available for passengers ☐ Yes

POF Codes:

☐ 01. Evaluation ☐ 02. Currency ☐ 03. Transportation ☐ 04. Check Flight ☐ 05. Logistics ☒ 06. R&D ☐ 07. Formal Training ☐ 08. Proficiency Q&S ☐ 10. Test & Ferry ☐ 15. Observation Flight ☐ 16. Other ☐ 17. Ground Time ☐ 19. Repositioning

Justification:

DATA COLLECTION AND SYSTEM EVALUATION IN ACCORDANCE WITH APPROVED FLIGHT TEST PLAN AND APPROVED WEEKLY FLIGHT SCHEDULE

Approval Required Before Flight	Signature	Printed Name / Title	Rtg Symbol	Date
7. Requested by				
8a. Approved by				
8b. Approved by				
8c. Chief or Regional Counsel Approval				

Aircraft Utilization Data

9. Registration (N) Number	10. Aircraft Make / Model	11. Aircraft Class	12. User Code	13. Cost Center	14. Reimbursement Acct.
40		33	T	RDFP	T2005H

15. Itinerary a. Date of Flight ___/___/___

a. Leg #	b. POF 1	c. POF 2	d. From	e. To	f. Block Out	g. Takeoff	h. Landing	i. Block In	j. Time in Service (TIS)	k. Total Time (TOT)	l. # of Passengers
1			ACY	MIA	1045	5088	5094	1315	2.3	2.5	
2											
3											
4											
5											
m. Totals									2.3	2.5	

16. Crew Member Accomplishments — Flight Time (Enter Flight Times in Hours and Tenths)

a. Crew #	b. Crew Name	c. PIC HRS	c. PIC 1/10	d. SIC HRS	d. SIC 1/10	e. Pilot HRS	e. Pilot 1/10	f. IP HRS	f. IP 1/10	g. FE HRS	g. FE 1/10	h. Other HRS	h. Other 1/10	i. Hood HRS	i. Hood 1/10	j. IMC HRS	j. IMC 1/10	k. Night HRS	k. Night 1/10	l. Takeoff D	l. Takeoff N	m. Landing D	m. Landing N	n. Hld #	o. Apprchs P	o. Apprchs N
CT014	Gilbert			2	5																					
CT010	Cooper	2	5			2	5																			
CT024	Tatham									2	5															
CT022	KAEGI											2	5													

21. Fuel Data

How Purchased: C = Commercial M = Military D = Contract B = Bulk O = Other

a. Fuel Ticket #	b. AV Gas or Jet Fuel	c. How Purchased	d. # Liters Purchased	e. # Gallons Purchased	f. Cost of Fuel
	☐ ☐			3,000	
	☐ ☐				
	☐ ☐				
	☐ ☐				
	☐ ☐				

20. Office Use Only DATA ENTRY	Initials	Date

FAA Form 4040-6 R&D Flight Program Only

AFTER FLIGHT: Return to Approving Office without Delay

(Use of FAA aircraft must be in compliance with Order 4040.9 as ammended)

Aircraft / Simulator Request and Approval Data

1. Source of Aircraft	2. Aircraft Type Desired	3. Date(s) Required	4. Type of Flight	5. Passenger Information
☒ FAA ☐ Rental	B727	Fm: 9 / 24 / 02 To: ___ / ___ / ___	FAR 91	Reportable to GSA ☐ Yes ☐ No Space Available for passengers ☐ Yes

POF Codes:

☐ 01. Evaluation	☐ 04. Check Flight	☐ 07. Formal Training	☐ 15. Observation Flight	☐ 17. Ground Time
☐ 02. Currency	☐ 05. Logistics	☐ 08. Proficiency Q&S	☐ 16. Other	☐ 19. Repositioning
☐ 03. Transportation	☒ 06. R&D	☐ 10. Test & Ferry		

Justification:

DATA COLLECTION AND SYSTEM EVALUATION IN ACCORDANCE WITH APPROVED FLIGHT TEST PLAN AND APPROVED WEEKLY FLIGHT SCHEDULE

Approval Required Before Flight	Signature	Printed Name / Title	Rtg Symbol	Date
7. Requested by				
8a. Approved by				
8b. Approved by				
8c. Chief or Regional Counsel Approval				

Aircraft Utilization Data

9. Registration (N) Number	10. Aircraft Make / Model	11. Aircraft Class	12. User Code	13. Cost Center	14. Reimbursement Acct.
4C1		33	T	RDFP	

15. Itinerary a. Date of Flight ___ / ___ / ___

a. Leg #	b. POF 1	c. POF 2	d. From	e. To	f. Block Out	g. Takeoff	h. Landing	i. Block In	j. Time in Service (TIS)	k. Total Time (TOT)	l. # of Passengers
1			MIA	SSJ	1245	5091.9	5098.2	1515	2.3	2.5	
2			SSJ	MIA	1630	5094.2	5096.4	2105	2.4	2.6	
3											
4											
5											
m. Totals									4.7	5.1	

16. Crew Member Accomplishments — Flight Time *(Enter Flight Times in Hours and Tenths)*

a. Crew #	b. Crew Name	c. PIC		d. SIC		e. Pilot		f. IP		g. FE		h. Other		i. Hood		j. IMC		k. Night		l. Takeoff		m. Landing		n. Hld	o. Approchs	
		HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	D	N	D	N	#	P	N
C+014	Elwhart	2	5	2	6	2	5									1	0			1		1			1	
010	Cooper	2	6	2	5	2	6									1	0			1		1			1	
024	THAM									5	1															
022	KAGI											5	1													

21. Fuel Data

How Purchased: C = Commercial M = Military D = Contract B = Bulk O = Other

a. Fuel Ticket #	b. AV Gas or Jet Fuel	c. How Purchased	d. # Liters Purchased	e. # Gallons Purchased	f. Cost of Fuel
JST MIA	☐ ☐			3,000	
	☐ ☐				
	☐ ☐				
	☐ ☐				
	☐ ☐				

20. Office Use Only DATA ENTRY	Initials	Date

FAA Form 4040-6 R&D Flight Program Only

AFTER FLIGHT: Return to Approving Office without Delay

(Use of FAA aircraft must be in compliance with Order 4040.9 as ammended)

Aircraft / Simulator Request and Approval Data

1. Source of Aircraft	2. Aircraft Type Desired	3. Date(s) Required	4. Type of Flight	5. Passenger Information
☒ FAA ☐ Rental	B727	Fm: 9/25/02 To: ___/___/___	FAR 91	Reportable to GSA ☐ Yes ☐ No Space Available for passengers ☐ Yes

POF Select

☐ 01. Evaluation ☐ 04. Check Flight ☐ 07. Formal Training ☐ 15. Observation Flight ☐ 17. Ground Time
☐ 02. Currency ☐ 05. Logistics ☐ 08. Proficiency Q&S ☐ 16. Other ☐ 19. Repositioning
☐ 03. Transportation ☒ 06. R&D ☐ 10. Test & Ferry

Justification:

DATA COLLECTION AND SYSTEM EVALUATION IN ACCORDANCE WITH APPROVED FLIGHT TEST PLAN AND APPROVED WEEKLY FLIGHT SCHEDULE

Approval Required Before Flight	Signature	Printed Name / Title	Rtg Symbol	Date
7. Requested by				
8a. Approved by				
8b. Approved by				
8c. Chief or Regional Counsel Approval				

Aircraft Utilization Data

9. Registration (N) Number	10. Aircraft Make / Model	11. Aircraft Class	12. User Code	13. Cost Center	14. Reimbursement Acct.
40		33	T	RDFP	

15. Itinerary a. Date of Flight ___/___/___

a. Leg #	b. POF 1	c. POF 2	d. From	e. To	f. Block Out	g. Takeoff	h. Landing	i. Block In	j. Time in Service (TIS)	k. Total Time (TOT)	l. # of Passengers
1			MIA	MIA	0845	5096.4	5099.5	1215	3.1	3.5	
2											
3											
4											
5											
m. Totals											

16. Crew Member Accomplishments — Flight Time (Enter Flight Times in Hours and Tenths)

a. Crew #	b. Crew Name	c. PIC		d. SIC		e. Pilot		f. IP		g. FE		h. Other		i. Hood		j. IMC		k. Night		l. Takeoff		m. Landing		n. Hld	o. Apprchs	
		HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	D	N	D	N	#	P	N
014	Ehrhart	3	5			3	5									1	0			1		1		1	1	
010	Gerpan			3	5											1	0									
025	THTHAM									3	5															

21. Fuel Data

How Purchased: C = Commercial M = Military D = Contract B = Bulk O = Other

a. Fuel Ticket #	b. AV Gas or Jet Fuel	c. How Purchased	d. # Liters Purchased	e. # Gallons Purchased	f. Cost of Fuel
	☐ ☐			4300	
	☐ ☐				
	☐ ☐				
	☐ ☐				
	☐ ☐				

20. Office Use Only DATA ENTRY	Initials	Date

FAA Form 4040-6 R&D Flight Program Only

AFTER FLIGHT: Return to Approving Office without Delay

(Use of FAA aircraft must be in compliance with Order 4040.9 as ammended)

Aircraft / Simulator Request and Approval Data

1. Source of Aircraft	2. Aircraft Type Desired	3. Date(s) Required	4. Type of Flight	5. Passenger Information
☒ FAA ☐ Rental	B727	Fm: 9/26/02 To: ___/___/___	FAR 91	Reportable to GSA ☐ Yes ☐ No Space Available for passengers ☐ Yes

POF Codes:

☐ 01. Evaluation ☐ 02. Currency ☐ 03. Transportation ☐ 04. Check Flight ☒ 06. R&D ☐ 05. Logistics ☐ 07. Formal Training ☐ 08. Proficiency Q&S ☐ 10. Test & Ferry ☐ 15. Observation Flight ☐ 16. Other ☐ 17. Ground Time ☐ 19. Repositioning

Justification:

DATA COLLECTION AND SYSTEM EVALUATION IN ACCORDANCE WITH APPROVED FLIGHT TEST PLAN AND APPROVED WEEKLY FLIGHT SCHEDULE

Approval Required Before Flight	Signature	Printed Name / Title	Rtg Symbol	Date
7. Requested by				
8a. Approved by				
8b. Approved by				
8c. Chief or Regional Counsel Approval				

Aircraft Utilization Data

9. Registration (N) Number	10. Aircraft Make / Model	11. Aircraft Class	12. User Code	13. Cost Center	14. Reimbursement Acct.
N40	B	33	T	RDFP	

15. Itinerary a. Date of Flight ___/___/___

a. Leg #	b. POF 1	c. POF 2	d. From	e. To	f. Block Out	g. Takeoff	h. Landing	i. Block In	j. Time in Service (TIS)	k. Total Time (TOT)	l. # of Passengers
1			MIA	MIA	0910	5095	5101.9	1145	2.4	2.6	
2			MIA	ACY	1315	5101.9	5109.0	1550	2.1	2.5	
3											
4											
5											
m. Totals									4.5	5.1	

16. Crew Member Accomplishments — **Flight Time** *(Enter Flight Times in Hours and Tenths)*

a. Crew #	b. Crew Name	c. PIC HRS	c. PIC 1/10	d. SIC HRS	d. SIC 1/10	e. Pilot HRS	e. Pilot 1/10	f. IP HRS	f. IP 1/10	g. FE HRS	g. FE 1/10	h. Other HRS	h. Other 1/10	i. Hood HRS	i. Hood 1/10	j. IMC HRS	j. IMC 1/10	k. Night HRS	k. Night 1/10	l. Takeoff D	l. Takeoff N	m. Landing D	m. Landing N	n. Hld #	o. Apprchs P	o. Apprchs N
CT 010	Cooper	2	6	2	5	2	6									2	0			1		1			1	
014	Emhert	2	5	2	6	2	5									2	0			1		1			1	
025	THAHAM									5	1															

21. Fuel Data

How Purchased: C = Commercial M = Military D = Contract B = Bulk O = Other

a. Fuel Ticket #	b. AV Gas or Jet Fuel	c. How Purchased	d. # Liters Purchased	e. # Gallons Purchased	f. Cost of Fuel
	☐ ☐		4052		
	☐ ☐		3,020		
	☐ ☐		2072		
	☐ ☐				
	☐ ☐				

20. Office Use Only DATA ENTRY	Initials	Date

FAA Form 4040-6 R&D Flight Program Only

AFTER FLIGHT: Return to Approving Office without Delay

(Use of FAA aircraft must be in compliance with Order 4040.9 as ammended)

Aircraft / Simulator Request and Approval Data

1. Source of Aircraft	2. Aircraft Type Desired	3. Date(s) Required	4. Type of Flight	5. Passenger Information
☒ FAA ☐ Rental	B 727	Fm: 9 / 30 / 02 To: 9 / 30 / 02	FAR 91	Reportable to GSA ☐ Yes ☐ No Space Available for passengers ☐ Yes

6. POF Codes:

☐ 01. Evaluation ☐ 04. Check Flight ☐ 07. Formal Training ☐ 15. Observation Flight ☐ 17. Ground Time
☐ 02. Currency ☐ 05. Logistics ☐ 08. Proficiency Q&S ☐ 16. Other ☐ 19. Repositioning
☐ 03. Transportation ☒ 06. R&D ☐ 10. Test & Ferry

Justification:

DATA COLLECTION AND SYSTEM EVALUATION IN ACCORDANCE WITH APPROVED FLIGHT TEST PLAN AND APPROVED WEEKLY FLIGHT SCHEDULE

Approval Required Before Flight	Signature	Printed Name / Title	Rtg Symbol	Date
7. Requested by				
8a. Approved by				
8b. Approved by				
8c. Chief or Regional Counsel Approval				

Aircraft Utilization Data

9. Registration (N) Number	10. Aircraft Make / Model	11. Aircraft Class	12. User Code	13. Cost Center	14. Reimbursement Acct.
N40	B-727	33	T	RDFP	T0710E

15. Itinerary a. Date of Flight ____/____/____

a. Leg #	b. POF 1	c. POF 2	d. From	e. To	f. Block Out	g. Takeoff	h. Landing	i. Block In	j. Time in Service (TIS)	k. Total Time (TOT)	l. # of Passengers
1			KACY	KGTF	0930	5104.0	5108.1	1350	4.1	4.3	
2			KGTF	KBFI	1450	5108.1	5109.4	1620	1.3	1.5	
3			KBFI	KBFI	1815	5109.4	5111.7	2050	2.3	2.6	
4											
5											
m. Totals									7.7	8.4	

16. Crew Member Accomplishments — Flight Time *(Enter Flight Times in Hours and Tenths)*

a. Crew #	b. Crew Name	c. PIC		d. SIC		e. Pilot		f. IP		g. FE		h. Other		i. Hood		j. IMC		k. Night		l. Takeoff		m. Landing		n. Hld	o. Apprchs	
		HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	D	N	D	N	#	P	N
CT006	BIEHL	4	1	4	3	4	1									2	3			1		1			11	
CT007	VAN HOY	4	3	4	1	4	3									2	3			1		1				
CT023	CAETANO									8	4															
CT021	BIRNEY																									

21. Fuel Data

How Purchased: C = Commercial M = Military D = Contract B = Bulk O = Other

a. Fuel Ticket #	b. AV Gas	or Jet Fuel	c. How Purchased	d. # Liters Purchased	e. # Gallons Purchased	f. Cost of Fuel
2278462	☐	☒	D		5564	
	☐	☐				
	☐	☐				
	☐	☐				
	☐	☐				

20. Office Use Only	Initials	Date
DATA ENTRY		

FAA Form 4040-6 R&D Flight Program Only

AFTER FLIGHT: Return to Approving Office without Delay

(Use of FAA aircraft must be in compliance with Order 4040.9 as ammended)

Aircraft / Simulator Request and Approval Data

1. Source of Aircraft	2. Aircraft Type Desired	3. Date(s) Required	4. Type of Flight	5. Passenger Information
X FAA ☐ Rental	B727	Fm: 10 / 1 / 02 To: 10 / 1 / 02	FAR 91	Reportable to GSA ☐ Yes ☐ No Space Available for passengers ☐ Yes

6. POF Codes:

☐ 01. Evaluation	☐ 04. Check Flight	☐ 07. Formal Training	☐ 15. Observation Flight	☐ 17. Ground Time
☐ 02. Currency	☐ 05. Logistics	☐ 08. Proficiency Q&S	☐ 16. Other	☐ 19. Repositioning
☐ 03. Transportation	X 06. R&D	☐ 10. Test & Ferry		

Justification:

DATA COLLECTION AND SYSTEM EVALUATION IN ACCORDANCE WITH APPROVED FLIGHT TEST PLAN AND APPROVED WEEKLY FLIGHT SCHEDULE

Approval Required Before Flight	Signature	Printed Name / Title	Rtg Symbol	Date
7. Requested by				
8a. Approved by				
8b. Approved by				
8c. Chief of Regional Counsel Approval				

Aircraft Utilization Data

9. Registration (N) Number	10. Aircraft Make / Model	11. Aircraft Class	12. User Code	13. Cost Center	14. Reimbursement Acct.
N40	B727	33	T	RDFP	T-0710E

15. Itinerary a. Date of Flight 10 / 1 / 02

a. Leg #	b. POF 1	c. POF 2	d. From	e. To	f. Block Out	g. Takeoff	h. Landing	i. Block In	j. Time in Service (TIS)	k. Total Time (TOT)	l. # of Passengers
1			KBFI	KBFI	0825	5111.7	5114.1	1110	2.3	2.8	
2			KBFI	KBFI	1405	5114.1	5116.4	1635	2.3	2.5	
3											
4											
5											
m. Totals									4.6	5.3	

16. Crew Member Accomplishments — Flight Time *(Enter Flight Times in Hours and Tenths)*

a. Crew #	b. Crew Name	c. PIC		d. SIC		e. Pilot		f. IP		g. FE		h. Other		i. Hood		j. IMC		k. Night		l. Takeoff		m. Landing		n. Hld	o. Apprchs.	
		HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	D	N	D	N	#	P	N
CT006	BIEHL	2	5	2	8	2	5									1	5			1		1			10	
CT007	VANHOY	2	8	2	5	2	8									1	5			1		1			10	
CT023	GAETANO									5	3															

21. Fuel Data

How Purchased: C = Commercial M = Military D = Contract B = Bulk O = Other

a. Fuel Ticket #	b. AV Gas or Jet Fuel	c. How Purchased	d. # Liters Purchased	e. # Gallons Purchased	f. Cost of Fuel
	☐ ☐				
	☐ ☐				
	☐ ☐				
	☐ ☐				
	☐ ☐				

20. Office Use Only	Initials	Date
DATA ENTRY		

FAA Form 4040-6 R&D Flight Program Only

AFTER FLIGHT: Return to Approving Office without Delay

(Use of FAA aircraft must be in compliance with Order 4040.9 as ammended)

Aircraft / Simulator Request and Approval Data

1. Source of Aircraft	2. Aircraft Type Desired	3. Date(s) Required	4. Type of Flight	5. Passenger Information
☒ FAA ☐ Rental	B727	Fm: 10 / 2 / 02 To: 10 / 2 / 02	FAR 91	Reportable to GSA ☐ Yes ☐ No Space Available for passengers ☐ Yes

POF Codes:

☐ 01. Evaluation	☐ 04. Check Flight	☐ 07. Formal Training	☐ 15. Observation Flight	☐ 17. Ground Time
☐ 02. Currency	☐ 05. Logistics	☐ 08. Proficiency Q&S	☐ 16. Other	☐ 19. Repositioning
☐ 03. Transportation	☒ 06. R&D	☐ 10. Test & Ferry		

Justification:

DATA COLLECTION AND SYSTEM EVALUATION IN ACCORDANCE WITH APPROVED FLIGHT TEST PLAN AND APPROVED WEEKLY FLIGHT SCHEDULE

Approval Required Before Flight	Signature	Printed Name / Title	Rtg Symbol	Date
7. Requested by				
8a. Approved by				
8b. Approved by				
8c. Chief or Regional Counsel Approval				

Aircraft Utilization Data

9. Registration (N) Number	10. Aircraft Make / Model	11. Aircraft Class	12. User Code	13. Cost Center	14. Reimbursement Acct.
N40	B727	33	T	RDFP	T-0710 E

15. Itinerary a. Date of Flight 10 / 2 / 02

a. Leg #	b. POF 1	c. POF 2	d. From	e. To	f. Block Out	g. Takeoff	h. Landing	i. Block In	j. Time in Service (TIS)	k. Total Time (TOT)	l. # of Passengers
1			KBFI	KBFI	0820	5116.4	5118.7	1055	2.3	2.6	
2											
3											
4											
5											
m. Totals									2.3	2.6	

16. Crew Member Accomplishments — Flight Time *(Enter Flight Times in Hours and Tenths)*

a. Crew #	b. Crew Name	c. PIC		d. SIC		e. Pilot		f. IP		g. FE		h. Other		i. Hood		j. IMC		k. Night		l. Takeoff		m. Landing		n. Hld	o. Apprchs	
		HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	D	N	D	N	#	P	N
CT006	BIEHL			2	6																					
CT007	VANHOY	2	6			2	6							1	5					1		1			10	
CT023	GAETANO									2	6			⊕												

21. Fuel Data

How Purchased: C = Commercial M = Military D = Contract B = Bulk O = Other

a. Fuel Ticket #	b. AV Gas or Jet Fuel	c. How Purchased	d. # Liters Purchased	e. # Gallons Purchased	f. Cost of Fuel
	☐ ☒				
	☐ ☐				
	☐ ☐				
	☐ ☐				
	☐ ☐				

20. Office Use Only	Initials	Date
DATA ENTRY		

FAA Form 4040-6 R&D Flight Program Only

AFTER FLIGHT: Return to Approving Office without Delay

(Use of FAA aircraft must be in compliance with Order 4040.9 as ammended)

Aircraft / Simulator Request and Approval Data

1. Source of Aircraft	2. Aircraft Type Desired	3. Date(s) Required	4. Type of Flight	5. Passenger Information
☒ FAA ☐ Rental	B727	Fm: 10/3/02 To: 10/3/02	FAR 91	Reportable to GSA ☐ Yes ☐ No Space Available for passengers ☐ Yes

POF Codes:

☐ 01. Evaluation ☐ 04. Check Flight ☐ 07. Formal Training ☐ 15. Observation Flight ☐ 17. Ground Time
☐ 02. Currency ☐ 05. Logistics ☐ 08. Proficiency Q&S ☐ 16. Other ☐ 19. Repositioning
☐ 03. Transportation ☒ 06. R&D ☐ 10. Test & Ferry

Justification:

DATA COLLECTION AND SYSTEM EVALUATION IN ACCORDANCE WITH APPROVED FLIGHT TEST PLAN AND APPROVED WEEKLY FLIGHT SCHEDULE

Approval Required Before Flight	Signature	Printed Name / Title	Rtg Symbol	Date
7. Requested by				
8a. Approved by				
8b. Approved by				
8c. Chief or Regional Counsel Approval				

Aircraft Utilization Data

9. Registration (N) Number	10. Aircraft Make / Model	11. Aircraft Class	12. User Code	13. Cost Center	14. Reimbursement Acct.
N40	B727	33	T	RDFP	T-0710 E

15. Itinerary a. Date of Flight 10/3/02

a. Leg #	b. POF 1	c. POF 2	d. From	e. To	f. Block Out	g. Takeoff	h. Landing	i. Block In	j. Time in Service (TIS)	k. Total Time (TOT)	l. # of Passengers
1			KBFI	KGRB	0950	5118.7	5121.8	1310	3.1	3.3	
2			KGRB	KGRB	1440	5121.8	5124.4	1745	2.6	3.1	
3											
4											
5											
m. Totals									5.7	6.4	

16. Crew Member Accomplishments — Flight Time *(Enter Flight Times in Hours and Tenths)*

a. Crew #	b. Crew Name	c. PIC HRS	c. PIC 1/10	d. SIC HRS	d. SIC 1/10	e. Pilot HRS	e. Pilot 1/10	f. IP HRS	f. IP 1/10	g. FE HRS	g. FE 1/10	h. Other HRS	h. Other 1/10	i. Hood HRS	i. Hood 1/10	j. IMC HRS	j. IMC 1/10	k. Night HRS	k. Night 1/10	l. Takeoff D	l. Takeoff N	m. Landing D	m. Landing N	n. Hld #	o. Apprchs P	o. Apprchs N
CT006	BIEHL	3	3	3	1	3	3									1	1	1	2	1		1			1	
CT007	VANHOY	3	1	3	3	3	1							1	8	1	1	1	2	1			1		15	
CT023	GAETANO																									
CT024	BIRNEY																									

21. Fuel Data

How Purchased: C = Commercial M = Military D = Contract B = Bulk O = Other

a. Fuel Ticket #	b. AV Gas or Jet Fuel	c. How Purchased	d. # Liters Purchased	e. # Gallons Purchased	f. Cost of Fuel
	☐ ☐				
	☐ ☐				
	☐ ☐				
	☐ ☐				
	☐ ☐				

20. Office Use Only DATA ENTRY | Initials | Date

FAA Form 4040-6 R&D Flight Program Only

AFTER FLIGHT: Return to Approving Office without Delay

(Use of FAA aircraft must be in compliance with Order 4040.9 as ammended)

Aircraft / Simulator Request and Approval Data

1. Source of Aircraft	2. Aircraft Type Desired	3. Date(s) Required	4. Type of Flight	5. Passenger Information
☒ FAA ☐ Rental	B727	Fm: 10 / 4 / 02 To: 10 / 4 / 02	FAR 91	Reportable to GSA ☐ Yes ☐ No Space Available for passengers ☐ Yes

6. POF Codes:

☐ 01. Evaluation	☐ 04. Check Flight	☐ 07. Formal Training	☐ 15. Observation Flight	☐ 17. Ground Time
☐ 02. Currency	☐ 05. Logistics	☐ 08. Proficiency Q&S	☐ 16. Other	☐ 19. Repositioning
☐ 03. Transportation	☒ 06. R&D	☐ 10. Test & Ferry		

Justification:

DATA COLLECTION AND SYSTEM EVALUATION IN ACCORDANCE WITH APPROVED FLIGHT TEST PLAN AND APPROVED WEEKLY FLIGHT SCHEDULE

Approval Required Before Flight	Signature	Printed Name / Title	Rtg Symbol	Date
7. Requested by				
8a. Approved by				
8b. Approved by				
8c. Chief or Regional Counsel Approval				

Aircraft Utilization Data

9. Registration (N) Number	10. Aircraft Make / Model	11. Aircraft Class	12. User Code	13. Cost Center	14. Reimbursement Acct.
N40	B727	33	T	RDFP	T-0710E

15. Itinerary a. Date of Flight 10 / 4 / 02

a. Leg #	b. POF 1	c. POF 2	d. From	e. To	f. Block Out	g. Takeoff	h. Landing	i. Block In	j. Time in Service (TIS)	k. Total Time (TOT)	l. # of Passengers
1			KGRB	KACY	1020	5124.4	5126.1	1230	1.7	2.2	
2											
3											
4											
5											
m. Totals									1.7	2.2	

16. Crew Member Accomplishments — Flight Time *(Enter Flight Times in Hours and Tenths)*

a. Crew #	b: Crew Name	c. PIC		d. SIC		e. Pilot		f. IP		g. FE		h. Other		i. Hood		j. IMC		k. Night		l. Takeoff		m. Landing		n. Hld	o. Apprchs	
		HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	D	N	D	N	#	P	N
CT006	BIEHL	2	2			2	2									1	5			1		1			1	
CT007	VANHOY			2	2											1	5									
CT023	GAETANO									2	2															
CT022	BIRNEY																									

21. Fuel Data

How Purchased: C = Commercial M = Military D = Contract B = Bulk O = Other

a. Fuel Ticket #	b. AV Gas or Jet Fuel	c. How Purchased	d. # Liters Purchased	e. # Gallons Purchased	f. Cost of Fuel
	☐ ☐				
	☐ ☐				
	☐ ☐				
	☐ ☐				
	☐ ☐				

20. Office Use Only DATA ENTRY	Initials	Date

FAA Form 4040-6 R&D Flight Program Only

AFTER FLIGHT: Return to Approving Office without Delay

(Use of FAA aircraft must be in compliance with Order 4040.9 as ammended)

Aircraft / Simulator Request and Approval Data

1. Source of Aircraft	2. Aircraft Type Desired	3. Date(s) Required	4. Type of Flight	5. Passenger Information
[X] FAA [ ] Rental	B727	Fm: 10 / 6 / 02 To: 10 / 16 / 02	FAR 91	Reportable to GSA [ ] Yes [ ] No Space Available for passengers [ ] Yes

JF Codes:

[ ] 01. Evaluation	[ ] 04. Check Flight	[ ] 07. Formal Training	[ ] 15. Observation Flight	[ ] 17. Ground Time
[ ] 02. Currency	[ ] 05. Logistics	[ ] 08. Proficiency Q&S	[ ] 16. Other	[ ] 19. Repositioning
[ ] 03. Transportation	[X] 06. R&D	[ ] 10. Test & Ferry		

Justification:

DATA COLLECTION AND SYSTEM EVALUATION IN ACCORDANCE WITH APPROVED FLIGHT TEST PLAN AND APPROVED WEEKLY FLIGHT SCHEDULE

Approval Required Before Flight	Signature	Printed Name / Title	Rtg Symbol	Date
7. Requested by				
8a. Approved by				
8b. Approved by				
8c. Chief of Regional Counsel Approval				

Aircraft Utilization Data

9. Registration (N) Number	10. Aircraft Make / Model	11. Aircraft Class	12. User Code	13. Cost Center	14. Reimbursement Acct.
N40	B727	33	T	RDFP	T-0710E

15. Itinerary a. Date of Flight 10 / 16 / 02

a. Leg #	b. POF 1	c. POF 2	d. From	e. To	f. Block Out	g. Takeoff	h. Landing	i. Block In	j. Time in Service (TIS)	k. Total Time (TOT)	l. # of Passengers
1			KACY	KGRB	0910	5126.1	5127.9	1110	1.8	2.0	
2			KGRB	KGRB	1250	5127.9	5130.0	1510	2.1	2.3	
3											
4											
5											
m. Totals									3.9	4.3	

16. Crew Member Accomplishments — Flight Time *(Enter Flight Times in Hours and Tenths)*

a. Crew #	b. Crew Name	c. PIC		d. SIC		e. Pilot		f. IP		g. FE		h. Other		i. Hood		j. IMC		k. Night		l. Takeoff		m. Landing		n. Hld	o. Apprchs	
		HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	D	N	D	N	#	P	N
CT006	BIEHL	2	3	2	0	2	3							1	1	1	1			1		1			10	
CT007	VANHOY	2	0	2	3	2	0									1	1			1		1			1	
CT023	GAETANO																									
CT021	BIRNEY																									

21. Fuel Data

How Purchased: C = Commercial M = Military D = Contract B = Bulk O = Other

a. Fuel Ticket #	b. AV Gas or Jet Fuel	c. How Purchased	d. # Liters Purchased	e. # Gallons Purchased	f. Cost of Fuel
762050	[ ] [X]	D		1304	
762051	[ ] [X]	D		3260	
	[ ] [ ]				
	[ ] [ ]				
	[ ] [ ]				

20. Office Use Only DATA ENTRY	Initials	Date

FAA Form 4040-6 R&D Flight Program Only

AFTER FLIGHT: Return to Approving Office without Delay

(Use of FAA aircraft must be in compliance with Order 4040.9 as ammended)

Aircraft / Simulator Request and Approval Data

1. Source of Aircraft	2. Aircraft Type Desired	3. Date(s) Required	4. Type of Flight	5. Passenger Information
☒ FAA ☐ Rental	B727	Fm: 10 / 7 / 02 To: 10 / 7 / 02	FAR 91	Reportable to GSA ☐ Yes ☐ No Space Available for passengers ☐ Yes

F Codes:

☐ 01. Evaluation	☐ 04. Check Flight	☐ 07. Formal Training	☐ 15. Observation Flight	☐ 17. Ground Time
☐ 02. Currency	☐ 05. Logistics	☐ 08. Proficiency Q&S	☐ 16. Other	☐ 19. Repositioning
☐ 03. Transportation	☒ 06. R&D	☐ 10. Test & Ferry		

Justification:

DATA COLLECTION AND SYSTEM EVALUATION IN ACCORDANCE WITH APPROVED FLIGHT TEST PLAN AND APPROVED WEEKLY FLIGHT SCHEDULE

Approval Required Before Flight	Signature	Printed Name / Title	Rtg Symbol	Date
7. Requested by				
8a. Approved by				
8b. Approved by				
8c. Chief or Regional Counsel Approval				

Aircraft Utilization Data

9. Registration (N) Number	10. Aircraft Make / Model	11. Aircraft Class	12. User Code	13. Cost Center	14. Reimbursement Acct.
N40	B727	33	T	RDFP	T-0710E

15. Itinerary a. Date of Flight 10 / 7 / 02

a. Leg #	b. POF 1	c. POF 2	d. From	e. To	f. Block Out	g. Takeoff	h. Landing	i. Block In	j. Time in Service (TIS)	k. Total Time (TOT)	l. # of Passengers
			LGRB	KGRB	0935	5130.0	5131.6	1125	1.6	1.8	
2											
3											
4											
5											
m. Totals									1.6	1.8	

16. Crew Member Accomplishments — Flight Time *(Enter Flight Times in Hours and Tenths)*

a. Crew #	b. Crew Name	c. PIC		d. SIC		e. Pilot		f. IP		g. FE		h. Other		i. Hood		j. IMC		k. Night		l. Takeoff		m. Landing		n. Hld	o. Apprchs	
		HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	D	N	D	N	#	P	N
CT006	BIEHL			1	8																					
CT007	VANHOY	1	8			1	8									1	1			1		1			10	
CT023	GAETANO									1	8															

21. Fuel Data

How Purchased: C = Commercial M = Military D = Contract B = Bulk O = Other

a. Fuel Ticket #	b. AV Gas	b. Jet Fuel	c. How Purchased	d. # Liters Purchased	e. # Gallons Purchased	f. Cost of Fuel
762052	☐	☒	D		3840	
	☐	☐				
	☐	☐				
	☐	☐				
	☐	☐				

20. Office Use Only DATA ENTRY	Initials	Date

FAA Form 4040-6 R&D Flight Program Only

AFTER FLIGHT: Return to Approving Office without Delay

(Use of FAA aircraft must be in compliance with Order 4040.9 as ammended)

Aircraft / Simulator Request and Approval Data

1. Source of Aircraft	2. Aircraft Type Desired	3. Date(s) Required	4. Type of Flight	5. Passenger Information
☒ FAA ☐ Rental	B727	Fm: 10 / 8 / 02 To: 10 / 8 / 02	FAR 91	Reportable to GSA ☐ Yes ☐ No Space Available for passengers ☐ Yes

F Codes:

☐ 01. Evaluation ☐ 02. Currency ☐ 03. Transportation ☐ 04. Check Flight ☐ 05. Logistics ☒ 06. R&D ☐ 07. Formal Training ☐ 08. Proficiency Q&S ☐ 10. Test & Ferry ☐ 15. Observation Flight ☐ 16. Other ☐ 17. Ground Time ☐ 19. Repositioning

Justification:

DATA COLLECTION AND SYSTEM EVALUATION IN ACCORDANCE WITH APPROVED FLIGHT TEST PLAN AND APPROVED WEEKLY FLIGHT SCHEDULE

Approval Required Before Flight	Signature	Printed Name / Title	Rtg Symbol	Date
7. Requested by				
8a. Approved by				
8b. Approved by				
8c. Chief of Regional Counsel Approval				

Aircraft Utilization Data

9. Registration (N) Number	10. Aircraft Make / Model	11. Aircraft Class	12. User Code	13. Cost Center	14. Reimbursement Acct.
N40	B727	33	T	RDFP	T-0710E

15. Itinerary a. Date of Flight 10 / 8 / 02

a. Leg #	b. POF 1	c. POF 2	d. From	e. To	f. Block Out	g. Takeoff	h. Landing	i. Block In	j. Time in Service (TIS)	k. Total Time (TOT)	l. # of Passengers
			KGRB	KGTF	0925	5131.6	5134.1	1205	2.5	2.7	
2			KGTF	KGTF	1355	5134.1	5135.7	1545	1.6	1.8	
3											
4											
5											
m. Totals									4.1	4.5	

16. Crew Member Accomplishments — Flight Time *(Enter Flight Times in Hours and Tenths)*

a. Crew #	b. Crew Name	c. PIC HRS	c. PIC 1/10	d. SIC HRS	d. SIC 1/10	e. Pilot HRS	e. Pilot 1/10	f. IP HRS	f. IP 1/10	g. FE HRS	g. FE 1/10	h. Other HRS	h. Other 1/10	i. Hood HRS	i. Hood 1/10	j. IMC HRS	j. IMC 1/10	k. Night HRS	k. Night 1/10	l. Takeoff D	l. Takeoff N	m. Landing D	m. Landing N	n. Hld #	o. Apprchs P	o. Apprchs N
CT006	BIEHL	2	7	1	8	2	7									1	3			1		1			1	
CT007	VANHOY	1	8	2	7	1	8							1	1	1	3			1		1			10	
CT023	GAETANO									4	5															
CT021	BIRNEY																									

21. Fuel Data

How Purchased: C = Commercial M = Military D = Contract B = Bulk O = Other

a. Fuel Ticket #	b. AV Gas or Jet Fuel	c. How Purchased	d. # Liters Purchased	e. # Gallons Purchased	f. Cost of Fuel
1682431	☐ ☒	D		2212	
770471	☐ ☒	D		2504	
	☐ ☐				
	☐ ☐				
	☐ ☐				

20. Office Use Only DATA ENTRY	Initials	Date

FAA Form 4040-6 R&D Flight Program Only

AFTER FLIGHT: Return to Approving Office without Delay

(Use of FAA aircraft must be in compliance with Order 4040.9 as ammended)

Aircraft / Simulator Request and Approval Data

1. Source of Aircraft	2. Aircraft Type Desired	3. Date(s) Required	4. Type of Flight	5. Passenger Information
[X] FAA [ ] Rental	B727	Fm: 10/9/02 To: 10/9/02	FAR 91	Reportable to GSA [ ] Yes [ ] No Space Available for passengers [ ] Yes

JF Codes:

[ ] 01. Evaluation [ ] 04. Check Flight [ ] 07. Formal Training [ ] 15. Observation Flight [ ] 17. Ground Time
[ ] 02. Currency [ ] 05. Logistics [ ] 08. Proficiency Q&S [ ] 16. Other [ ] 19. Repositioning
[ ] 03. Transportation [X] 06. R&D [ ] 10. Test & Ferry

Justification:

DATA COLLECTION AND SYSTEM EVALUATION IN ACCORDANCE WITH APPROVED FLIGHT TEST PLAN AND APPROVED WEEKLY FLIGHT SCHEDULE

Approval Required Before Flight	Signature	Printed Name / Title	Rtg Symbol	Date
7. Requested by				
8a. Approved by				
8b. Approved by				
8c. Chief of Regional Counsel Approval				

Aircraft Utilization Data

9. Registration (N) Number	10. Aircraft Make / Model	11. Aircraft Class	12. User Code	13. Cost Center	14. Reimbursement Acct.
N40	B727	33	T	RDFP	T-0710E

15. Itinerary a. Date of Flight 10/9/02

a. Leg #	b. POF 1	c. POF 2	d. From	e. To	f. Block Out	g. Takeoff	h. Landing	i. Block In	j. Time in Service (TIS)	k. Total Time (TOT)	l. # of Passengers
1			KGTF	KGTF	0855	5135.7	5137.3	1050	1.6	1.9	
2			KGTF	KGTF	1315	5137.3	5138.9	1500	1.6	1.7	
3											
4											
5											
m. Totals									3.2	3.6	

16. Crew Member Accomplishments — Flight Time *(Enter Flight Times in Hours and Tenths)*

a. Crew #	b. Crew Name	c. PIC		d. SIC		e. Pilot		f. IP		g. FE		h. Other		i. Hood		j. IMC		k. Night		l. Takeoff		m. Landing		n. Hld	o. Apprchs	
		HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	D	N	D	N	#	P	N
CT006	BIEHL	1	9	1	7	1	9							1	1					1		1			10	
CT007	VANHOY	1	7	1	9	1	7							1	1					1		1			10	
CT023	GAETANO									3	6			~~1~~	~~1~~											

21. Fuel Data

How Purchased: C = Commercial M = Military D = Contract B = Bulk O = Other

a. Fuel Ticket #	b. AV Gas	b. or Jet Fuel	c. How Purchased	d. # Liters Purchased	e. # Gallons Purchased	f. Cost of Fuel
4797432	[ ]	[X]	D		2522	
3581472	[ ]	[X]	D		2422	
	[ ]	[ ]				
	[ ]	[ ]				
	[ ]	[ ]				

20. Office Use Only — DATA ENTRY | Initials | Date

FAA Form 4040-6 R&D Flight Program Only

AFTER FLIGHT: Return to Approving Office without Delay

(Use of FAA aircraft must be in compliance with Order 4040.9 as ammended)

Aircraft / Simulator Request and Approval Data

1. Source of Aircraft	2. Aircraft Type Desired	3. Date(s) Required	4. Type of Flight	5. Passenger Information
☒ FAA ☐ Rental	B727	Fm: 10 / 10 / 02 To: 10 / 10 / 02	FAR 91	Reportable to GSA ☐ Yes ☐ No Space Available for passengers ☐ Yes

6. POF Codes:

☐ 01. Evaluation ☐ 02. Currency ☐ 03. Transportation ☐ 04. Check Flight ☐ 05. Logistics ☒ 06. R&D ☐ 07. Formal Training ☐ 08. Proficiency Q&S ☐ 10. Test & Ferry ☐ 15. Observation Flight ☐ 16. Other ☐ 17. Ground Time ☐ 19. Repositioning

Justification:

DATA COLLECTION AND SYSTEM EVALUATION IN ACCORDANCE WITH APPROVED FLIGHT TEST PLAN AND APPROVED WEEKLY FLIGHT SCHEDULE

Approval Required Before Flight	Signature	Printed Name / Title	Rtg Symbol	Date
7. Requested by				
8a. Approved by				
8b. Approved by				
8c. Chief or Regional Counsel Approval				

Aircraft Utilization Data

9. Registration (N) Number	10. Aircraft Make / Model	11. Aircraft Class	12. User Code	13. Cost Center	14. Reimbursement Acct.
			T	RDFP	

15. Itinerary a. Date of Flight ____/____/____

a. Leg #	b. POF 1	c. POF 2	d. From	e. To	f. Block Out	g. Takeoff	h. Landing	i. Block In	j. Time in Service (TIS)	k. Total Time (TOT)	l. # of Passengers
			KGTF	KGTF	0855	5138	5140.4	1045	1.5	1.8	
2											
3											
4											
5											
m. Totals											

16. Crew Member Accomplishments — **Flight Time** *(Enter Flight Times in Hours and Tenths)*

a. Crew #	b. Crew Name	c. PIC HRS	c. PIC 1/10	d. SIC HRS	d. SIC 1/10	e. Pilot HRS	e. Pilot 1/10	f. IP HRS	f. IP 1/10	g. FE HRS	g. FE 1/10	h. Other HRS	h. Other 1/10	i. Hood HRS	i. Hood 1/10	j. IMC HRS	j. IMC 1/10	k. Night HRS	k. Night 1/10	l. Takeoff D	l. Takeoff N	m. Landing D	m. Landing N	n. Hld #	o. Apprchs P	o. Apprchs N
CT006	BIEHL																									
CT007	VANHOY																									
CT023	GAETANO																									

21. Fuel Data

How Purchased: C = Commercial M = Military D = Contract B = Bulk O = Other

a. Fuel Ticket #	b. AV Gas or Jet Fuel	c. How Purchased	d. # Liters Purchased	e. # Gallons Purchased	f. Cost of Fuel
24734133	☐ / ☒	D		3944	
	☐ / ☐				
	☐ / ☐				
	☐ / ☐				
	☐ / ☐				

20. Office Use Only DATA ENTRY	Initials	Date

FAA Form 4040-6 R&D Flight Program Only

AFTER FLIGHT: Return to Approving Office without Delay

(Use of FAA aircraft must be in compliance with Order 4040.9 as ammended)

Aircraft / Simulator Request and Approval Data

1. Source of Aircraft	2. Aircraft Type Desired	3. Date(s) Required	4. Type of Flight	5. Passenger Information
~~X~~ FAA ☐ Rental	B727	Fm: 10 / 11 / 02 To: 10 / 11 / 02	FAR 91	Reportable to GSA ☐ Yes ☐ No Space Available for passengers ☐ Yes

F Codes:

☐ 01. Evaluation ☐ 04. Check Flight ☐ 07. Formal Training ☐ 15. Observation Flight ☐ 17. Ground Time
☐ 02. Currency ☐ 05. Logistics ☐ 08. Proficiency Q&S ☐ 16. Other ☐ 19. Repositioning
☐ 03. Transportation ☒ 06. R&D ☐ 10. Test & Ferry

Justification:

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7. Requested by				
8a. Approved by				
8b. Approved by				
8c. Chief or Regional Counsel Approval				

Aircraft Utilization Data

9. Registration (N) Number	10. Aircraft Make / Model	11. Aircraft Class	12. User Code	13. Cost Center	14. Reimbursement Acct.
N40	B727	33	T	RDFP	T-0710E

15. Itinerary a. Date of Flight 10 / 11 / 02

a. Leg #	b. POF 1	c. POF 2	d. From	e. To	f. Block Out	g. Takeoff	h. Landing	i. Block In	j. Time in Service (TIS)	k. Total Time (TOT)	l. # of Passengers
			KGTF	KAC4	0900	5140Z	5144.0	1250	3.6	3.8	
2											
3											
4											
5											
m. Totals									3.6	3.8	

16. Crew Member Accomplishments — Flight Time *(Enter Flight Times in Hours and Tenths)*

a. Crew #	b. Crew Name	c. PIC		d. SIC		e. Pilot		f. IP		g. FE		h. Other		i. Hood		j. IMC		k. Night		l. Takeoff		m. Landing		n. Hld	o. Approche	
		HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	HRS	1/10	D	N	D	N	#	P	N
CT-006	BIEHL			3	8											1	8									
CT-007	VANHOY	3	8			3	8									1	8			1		1			1	
CT-023	GAETANO									3	8															
CT-021	BIRNEY																									

21. Fuel Data

How Purchased: C = Commercial M = Military D = Contract B = Bulk O = Other

a. Fuel Ticket #	b. AV Gas or Jet Fuel	c. How Purchased	d. # Liters Purchased	e. # Gallons Purchased	f. Cost of Fuel
	☐ ☒			4627	
	☐ ☐				
	☐ ☐				
	☐ ☐				
	☐ ☐				

20. Office Use Only DATA ENTRY	Initials	Date

FAA Form 4040-6 R&D Flight Program Only

AFTER FLIGHT: Return to Approving Office without Delay

APPENDIX I—HENDRY TROUBLESHOOTING PROCEDURES

Arc Fault Circuit Breaker
Flight Test Program

Troubleshooting Procedures

for

Hendry Arc Fault Circuit Breaker (AFCB) Installation

on

FAA Technical Center
Boeing 727-25C Aircraft N40

15 June 2002

FAA William J. Hughes Technical Center
Engineering and Modification Section, ACT-370
Maintenance, Inspection, and Repair Section, AAR-433

Prepared by: R.A. Pappas, AAR-433

Reviewed by: J. Beres, ACT-370

Approved by: Armando Gaetano
Manager, Engineering & Modifications Section, ACT-370

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1.0 INTRODUCTION

This document defines the troubleshooting procedures to be used during the Arc Fault Circuit Breakers (AFCBs) performance evaluation on in an FAA owned Boeing 727-25C aircraft. The effort will be conducted by the United States (U.S.) Federal Aviation Administration (FAA) at the William J. Hughes Technical Center (WJHTC), Atlantic City, New Jersey.

1.1 BACKGROUND

The integration of arc fault detection into circuit breakers represents a revolutionary change in circuit protection; which has changed little in the last thirty to forty years. There is abundant evidence of arc faults in all types of aircraft. Laboratory data clearly demonstrates that the current generated during an arcing fault can be very high, yet quite intermittent. The bimetallic elements in thermal breakers do not react quickly enough, if at all, to this ticking arc fault condition. If left unchecked, the arcing condition can develop into an arc tracking condition, potentially destroying a major portion of, or an entire wire bundle. Arcing can also result in many other serious safety hazards.

In 1999, the FAA and the Navy established a joint R&D project to develop aircraft AFCBs. The goal of this effort is to develop a circuit breaker that integrates arc fault protection together with existing thermal protection into a form, fit, and functional replacement of existing thermal circuit breakers. In laboratory testing, the AFCB prototypes have been very effective in the detection of arcing faults.

In contrast to thermal breakers, which are passive in nature, AFCBs actively monitor the circuits on which they are installed. Due to the nature of electrical systems, there are times when a normal condition may ‘look’ similar to an arc fault. When such a condition trips an arc fault circuit breaker, it is defined as a nuisance trip. AFCB designs minimize the occurrence of nuisance tripping and maximize sensitivity to arc fault detection.

To address nuisance tripping, the FAA, Navy, and the AFCB developers, have conducted extensive tests to characterize the normal operation of electrical loads, and perturbations to electrical systems during normal events such as bus transfers, power on/off, transfer of power sources, etc. Laboratory tests today have provided a high level of confidence that nuisance tripping of AFCBs is being successfully controlled.

AFCB development has progressed to the point where flight tests are appropriate to demonstrate compliance with applicable Federal Aviation Regulations (FARs).

1.2 OBJECTIVE

The objective of this task is to conduct an in-flight evaluation of AFCB performance.

The Federal Aviation Administration (FAA), William J. Hughes Technical Center (WJHTC) R&D Flight Program is performing a minor modification to their Boeing 727-25C aircraft. This temporary modification involves the installation of eight AFCB prototypes manufactured by the Hendry corporation. The AFCBs are to be installed for a six-month evaluation period in support of AFCB research and development.

1.3 SCOPE

The scope of this effort is to install AFCBs manufactured by the Hendry corporation in an FAA owned Boeing 727-25C aircraft and conduct a flight evaluation of the developmental AFCBs. Data recorded includes line voltage, load voltage, and current for each of the installed breakers. Data reduction efforts of any occurring arc faults will include identification of relationships between the trip conditions.

2.0 FLIGHT TEST GOALS

The following list describes the goals of the experimental flight test program, listed in order of importance.

- Complete fifty (50) or more hours of developmental flight test evaluation but not less than twenty-five (25) hours. Data generated during these flights is critical to the AFCB research and development program and for obtaining approval of the N-40 one-only STC.
- Evaluate the operation of the arc fault circuit breakers under standard B727 operational procedures.
- Evaluate the operation of the AFCB instrumentation and Odyssey data recording system for future unmanned data collection.

3.0 SYSTEM DESCRIPTION

The equipment being installed for the Arc Fault flight evaluation includes developmental prototype AFCBs installed in a junction box, an instrumentation recorder and interconnecting cables and wire harnesses. These items are described in the following paragraphs.

3.1 ARC FAULT CIRCUIT BREAKERS

Eight (8) - Hendry prototype arc fault circuit breakers of the following ratings: one 2.5 A, three 5A, one 7.5A, one 10A, and two 15A (mounted in AFCI Junction Box).

3.2 ARC FAULT CIRCUIT INTERUPTER - JUNCTION BOX AND AIRCRAFT HARNESSES

One (1) – AFCI-JB.
Two (2) – AFCI-JB Test Unit wire harnesses, P18 and P6

3.3 INSTRUMENTATION EQUIPMENT

One (1) - 24 channel, Nicolet Odyssey data recorder.
One (1) – BNC Breakout Box.
One (1) – AFCI JB – BNC Breakout Box Interface Harness.
Twenty-four (24) – 24-inch BNC connector cables.
One (1) – Trigger Alarm

3.4 AIRCRAFT INTERFACES

The electrical connections for the system are shown schematically in FAA Drawing Number 9854415, Arc Fault Circuit Breaker Wiring. The AFCBs mounted within the AFCI-JB will be electrically in series with the load side of the existing circuit breakers. The AFCI-JB wire harnesses, P-18 and P-6, connect the load side of the each aircraft circuit breaker to the line side

of the respective AFCB and from the load side of the each AFCB to the feed wire for the respective load.

It is important to note that the AFCBs will be connected in series with the load side of the existing thermal circuit breakers. In other words, current circuit protection aboard the aircraft will not be compromised in any way by this installation.

The on-board Project Power Inverter provides 120VAC 60Hz power for the Data Acquisition System.

4.0 AIRCRAFT INSTALLATION

The AFCBs will be installed in an Arc Fault Circuit Interrupter-Junction Box (AFCI-JB) that will enclose all the AFCBs and required instrumentation interfaces. The AFCI-JB will be mounted in the rear, left side of the cockpit. The test unit will have bypass switches that will disable the AFCBs if desired.

The BNC Breakout Box and the Odyssey data recorder will be mounted in the cabin of the aircraft.

The electrical installation shall be completed in accordance with drawing number 9854415 under the guidance of the WJHTC Electrical Systems Designated Engineering Representative (DER), Code ACT-370. The mechanical installation shall be completed under the guidance of the WJHTC Mechanical Systems DER, Code ACT-370.

Detailed instructions for completing the installation can be found in the AFCB Ground Checkout Procedures Report.

5.0 CERTIFICATION REQUIREMENTS

There are no FAA Technical Standard Orders for the equipment being installed during this modification. Experimental flight test is being performed to collect data necessary to obtain a one only STC to install the AFCBs aboard N40 for an extended evaluation period.

6.0 ARC FAULT TROUBLESHOOTING

6.1 ARC FAULT TROUBLESHOOTING BACKGROUND

Although AFCBs can detect arcing on the circuit in which it is installed, it cannot determine the location of the arc along the circuit. Furthermore, means for easily troubleshooting an arc fault after and AFCB trip are under development but not currently available. This plan has been developed to establish a procedure for troubleshooting AFCB trips, should they occur.

An understanding of current methods of troubleshooting thermal trips will clarify the additional measures needed to troubleshoot an AFCB trip and specifically the procedures that will be followed during the FAA AFCB flight test program.

Troubleshooting circuit breakers is an iterative process. Generally, after a thermal circuit breaker trip, troubleshooting begins by evaluating the load(s) powered by the circuit. The load is either tested for correct operation, or is removed and replaced if its correct operation cannot be

directly determined. The circuit is powered and if no additional trips are noted the corrective action is considered complete.

If additional trips of the same circuit occur, there are several options for corrective action. The load may still be suspected, and the problem may not be reproducible on the ground. The circuit breaker itself may be suspect and replaced (tripping of thermal circuit breakers under normal conditions, or failure of a circuit breaker to stay closed when depressed, are two common circuit breaker failure modes). Usually, the last item to be checked is the circuit wiring, mainly because of the inherent difficulties in testing and inspecting the wiring.

AFCB's add another dimension of complexity to the troubleshooting problem. AFCB's have two trip modes, thermal (current overload) and arc fault. There are unique procedures for troubleshooting each mode, and unfortunately, if one procedure fails to identify the problem it may be necessary to complete the other procedure to be certain that the problem has been resolved. Future AFCB's will have the ability to indicate if the trip mode was thermal or arc fault related. The prototypes flown in this test program will not have this feature. However, the data recording instrumentation will be triggered by the AFCB's arc fault detection circuit and therefore it will be known with certainty if the trip mode was thermal versus arc fault.

If the trip mode was arc fault related, the question remains was the arc trip a real arc or was it a nuisance trip? The instrumentation being used in these flights will record the current waveforms immediately before and after the AFCB indicates that an arc is present and a trip is initiated. This data will be analyzed by Hendry Aerospace to determine if it appears to be a real arc or a nuisance trip. If it is certain that the trip was nuisance related, then the breaker will be reset and flights testing may resume. If a nuisance trip is not certain, then further diagnostics will be required.

Provisions have been made to baseline the condition of the wiring on the eight circuits that will be used in the tests with Time Domain Reflectometry (TDR). During ground testing of the AFCB test system, each AFCB equipped circuit will be characterized with TDR. This data will form a baseline measurement against which future measurements will be compared. Changes in the measurement indicate possible locations at which the arcing may have occurred.

At this point, it is unclear if TDR is sensitive enough to detect the damage incurred by a wire during an arcing condition. If the TDR fails to identify the location of the fault, visual inspection of the circuit must be performed to determine the source of the fault.

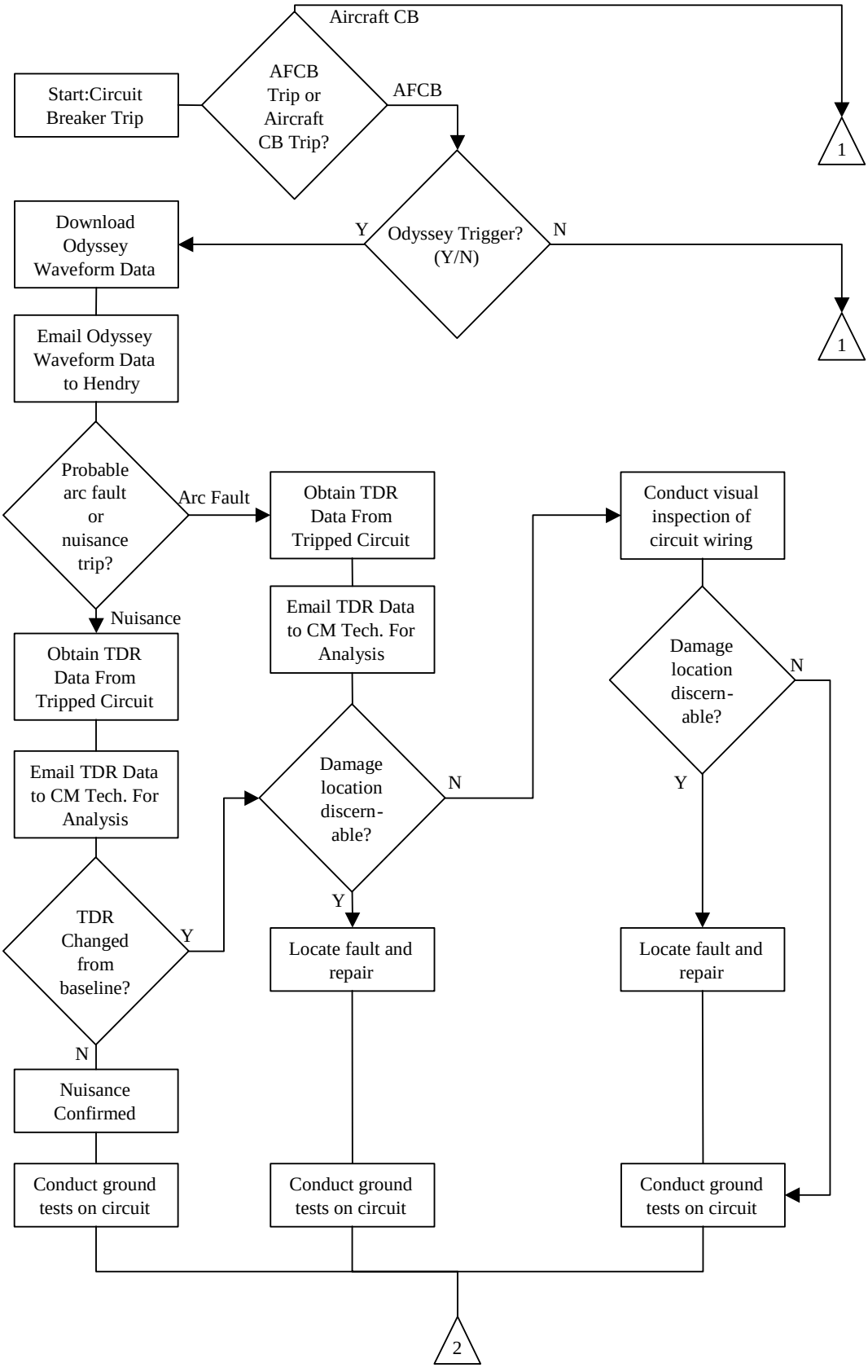
6.2 DETAILED TROUBLESHOOTING PROCEDURES

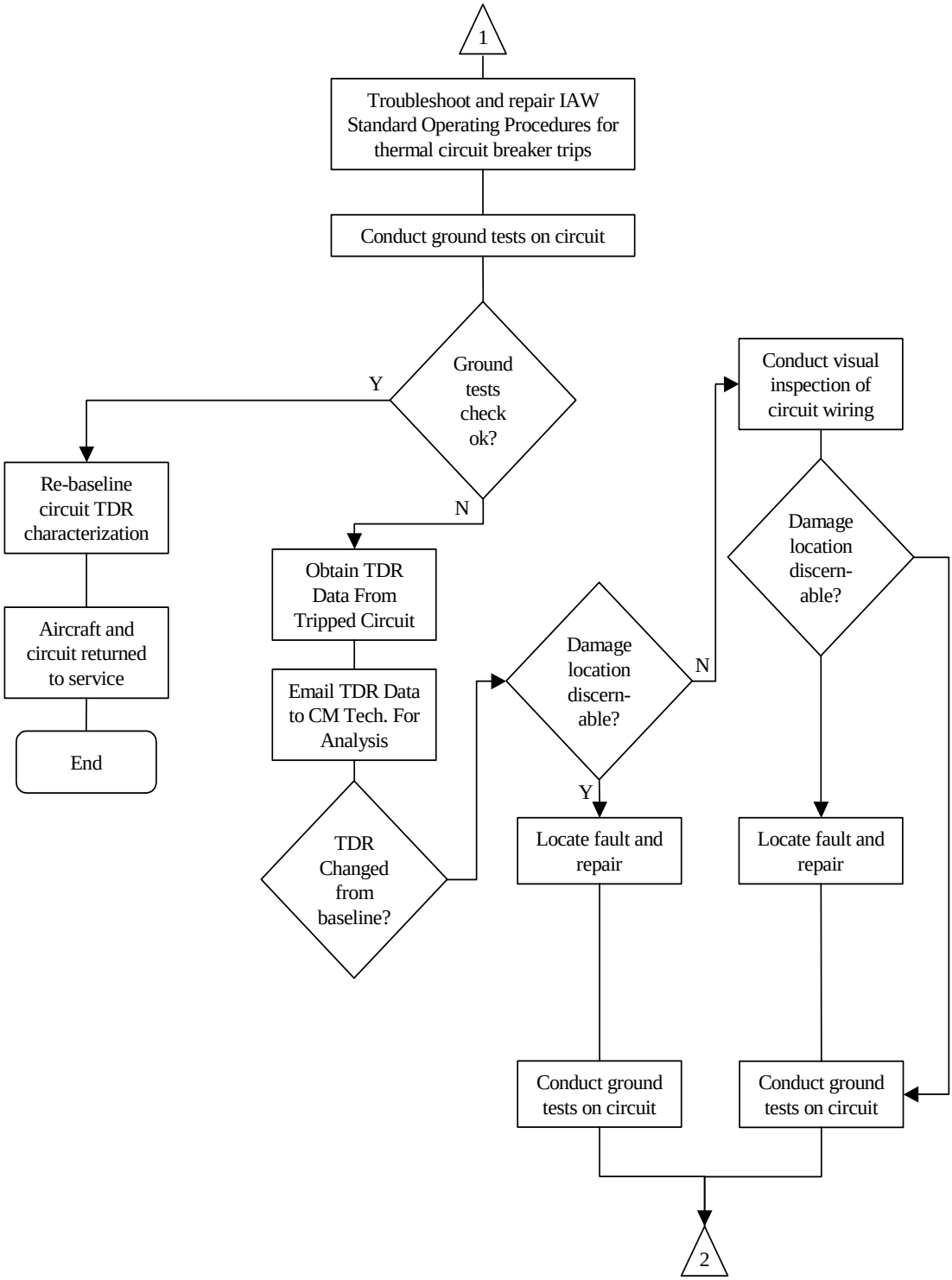
All troubleshooting shall be performed by qualified FAA personnel under the direction of the Electrical Systems DER, Code ACT-370.

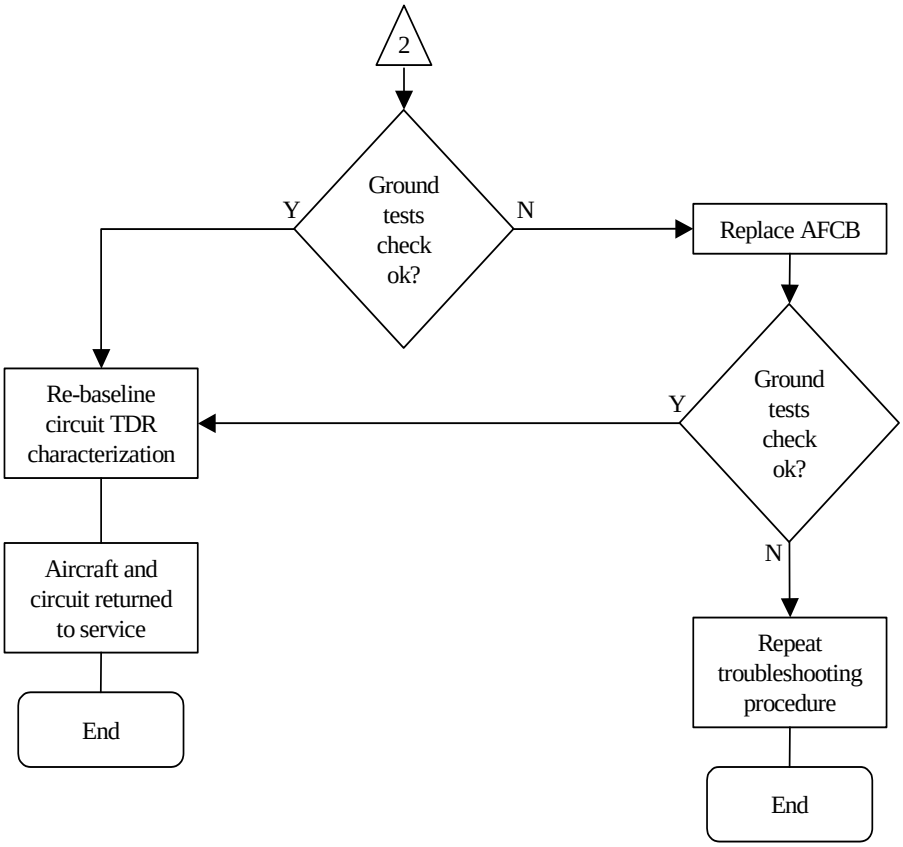
Upon an AFCB arc fault trip, the Odyssey data recording system will record the current and voltage waveforms from the eight circuits equipped with AFCB's. A thermal trip of the AFCB or the aircraft circuit breaker will not cause the Odyssey to trigger on and record this data. Therefore, it will be known immediately if the trip was caused by an arc fault.

Appendix A contains the detailed process flow charts.

APPENDIX A – TROUBLESHOOTING PROCESS FLOWCHARTS


Start:Circuit Breaker Trip
AFCB Trip or Aircraft CB Trip?
Aircraft CB
AFCB
1
Odyssey Trigger? (Y/N)
Y
N
Download Odyssey Waveform Data
Email Odyssey Waveform Data to Hendry
1
Probable arc fault or nuisance trip?
Arc Fault
Nuisance
Obtain TDR Data From Tripped Circuit
Email TDR Data to CM Tech. For Analysis
Damage location discern-able?
N
Y
Conduct visual inspection of circuit wiring
Damage location discern-able?
N
Y
Obtain TDR Data From Tripped Circuit
Email TDR Data to CM Tech. For Analysis
TDR Changed from baseline?
Y
N
Locate fault and repair
Locate fault and repair
Nuisance Confirmed
Conduct ground tests on circuit
Conduct ground tests on circuit
Conduct ground tests on circuit
2


1
Troubleshoot and repair IAW Standard Operating Procedures for thermal circuit breaker trips
Conduct ground tests on circuit
Ground tests check ok?
Y
N
Re-baseline circuit TDR characterization
Aircraft and circuit returned to service
End
Obtain TDR Data From Tripped Circuit
Email TDR Data to CM Tech. For Analysis
TDR Changed from baseline?
Damage location discern-able?
N
Y
Conduct visual inspection of circuit wiring
Damage location discern-able?
Locate fault and repair
Locate fault and repair
Conduct ground tests on circuit
Conduct ground tests on circuit
2


2
Ground tests check ok?
Y
N
Replace AFCB
Ground tests check ok?
Y
N
Re-baseline circuit TDR characterization
Aircraft and circuit returned to service
End
Repeat troubleshooting procedure
End

APPENDIX J—TIME DOMAIN REFLECTOMETER TEST RESULTS

Time Domain Reflectometer (TDR)
Test Results

for

Arc-Fault Circuit Breaker Flight Test Installation

On

FAA Technical Center
Boeing 727-25C Aircraft N40

Conducted by:

CM Technologies
27-28 August 2001

ECAD Testing
ARC Fault Circuit Breaker Wiring (Tail ID - N40)

On August 27 and 28, 2001, the ECAD Division of CM Technologies acquired preliminary data on selected circuits which are part of the FAA's Arc Fault Circuit Breaker Program. A detailed description of the circuits tested is as follows;

Circuit - AFCB1

Description: Left Inboard Landing Lights
Device Code: AFCB1_L_INBD_LNDG_LT
Drawing: E33-42-01
Test Area: Panel P18, Breaker C251
Test Set Up:
- Breaker C251 – open
- Left Inboard Landing Light Switch. S22 – closed
- Left Inboard Landing Light Transformer T5 – disconnected.

Testing configurations associated with this circuit:: 1, Test Cfg. A

Test Cfg. A: Test Lead – High (red clip) connected to load side of Brkr. C251, wire no. W508-136-20. Test Lead – Low (black clip) connected to ground. Circuit characterized from Brkr. to L22 light connection.

Circuit – AFCB2

Description: Oscillating Navigation Lights
Device Code: AFCB2_OSCIL_NAV_LT
Drawing: E33-43-01
Test Area: Panel P18, Breaker C258
Test Set Up:
- Breaker C258 - open
- Navigation Light Switch S17 – closed
- Right Green Navigation Light L12 – disconnected
- Left Red Navigation Light L13 – disconnected
- Tail White Navigation Light (and motor) L14 – disconnected.

Testing configurations associated with this circuit:: 7, Test Cfgs. A – G.
Note: Connector D4148J could not be located during the testing.

Test Cfg. A: Test Lead – High connected to load side of Brkr. C258, wire no. W508-110-20. Test Lead – Low connected to ground. Entire circuit characterized (including parallel paths).
Test Cfg. B: Test Lead – High connected to Pin 2 of connector D4470J, wire W376-002-20. Test Lead – Low connected to ground. Circuit characterized from

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connector D4470J to connector D454 (at L14). Connector D4470J remained disconnected from the circuit for the remaining test configurations.
Test Cfg. C: Test Lead – High connected to load side of Brkr. C258, wire no. W508-110-20. Test Lead – Low connected to ground. Connector D4310P was disconnected. Circuit characterized from Brkr. C258 to connector D4310P.
Test Cfg. D: Test Lead – High connected to Pin 13 of connector D4310P, wire W436-057-20. Test Lead – Low connected to ground. Circuit characterized from connector D4310P to Brkr. C258.
Test Cfg. E: Test Lead – High connected to Pin 17 of connector D4310P, wire W436-045-22. Test Lead – Low connected to ground. Circuit characterized from connector D4310P to Brkr. C258.
Test Cfg. F: Test Lead – High connected to Pin 13 of connector D4310J, wire W436-013-22. Test Lead – Low connected to ground. Circuit characterized from connector D4310J to Right Green Navigation Light (L12) connector D450.
Test Cfg. G: Test Lead – High connected to Pin 17 of connector D4310J, wire W068-017-22. Test Lead – Low connected to ground. Circuit characterized from connector D4310J to Left Red Navigation Light (L13) connector D452.

Circuit AFCB3

Description: Window Lights Left Side
Device Code: AFCB3_WNDW_LITE_LEFT
Drawing: E33-21-11
Test Area: Panel P18, Breaker C1023
Test Set Up:

- Breaker C1023- open
- Jumper installed between A1 & A2 contacts of R625 Window Light Relay
- Lead LV and HV1 removed from T158 Window Light Transformer
- Leads LV and HV1 were bolted together

Testing configurations associated with this circuit:: 3, Test Cfgs. A-C.

Test Cfg. A: Test Lead – High connected to load side of Brkr. C1023, wire no. W508-179-18. Test Lead – Low connected to ground. Entire circuit characterized (including parallel paths, and loads).
Test Cfg. B: Test Lead – High connected to Pin 17 of connector D4878J, wire W306-685-20. Test Lead – Low connected to ground. Circuit characterized from connector D4878J to numerous parallel light circuits.
Test Cfg. C: Test Lead – High connected to Pin 18 of connector D4878J, wire W306-684-20. Test Lead – Low connected to ground. Circuit characterized from connector D4878J to numerous parallel light circuits

Circuit AFCB4

Description: Passenger Ceiling Lights Left Side

Device Code: AFCB4_PSGR_CEIL_LT_L
Drawing: E33-22-02
Test Area: Panel P18, Breaker C273
Test Set Up:

- Breaker C273 - open
- Jumper installed between T1 & L1 contacts of R626 Ceiling Lt Relay
- Lead HV1 and HV2 removed from T24 Ceiling Lights Transformer
- Leads HV1 and HV2 were bolted together

Testing configurations associated with this circuit:: 2, Test Cfgs. A & B.

Test Cfg. A: Test Lead – High connected to load side of Brkr. C273, wire no. W508-671-16. Test Lead – Low connected to ground. Entire circuit characterized (including parallel paths, and loads).
Test Cfg. B: Test Lead – High connected to load side of Brkr. C273, wire no. W508-671-16. Test Lead – Low connected to ground. Connector D4490P was disconnected, and circuit was characterized from Brkr. C273 to connector D4490P (no loads).

Circuit AFCB5

Description: DME No. 2
Device Code: AFCB5_DME_NO_2
Drawing: E.O. 23269
Test Area: Panel P18, Breaker C73
Test Set Up:

- Breaker C73 – open

Testing configurations associated with this circuit:: 1, Test Cfg. A

Test Cfg. A: Test Lead – High connected to load side of Brkr. C73, wire no. W033-099-22. Test Lead – Low connected to ground. Entire circuit characterized from Brkr. C73 to K1 Relay.

Circuit AFCB6

Description: Heater – Pitot – Aux.
Device Code: AFCB6_HTR_PITOT_AUX
Drawing: E30-31-01
Test Area: Panel P6, Breaker C137
Test Set Up:

- Breaker C137 – open
- Jumper installed between Pin 4 of D4080P and Pin 10 of D4080J
- A21 Auxiliary Pitot Heater disconnected

Testing configurations associated with this circuit:: 1, Test Cfg. A

Test Cfg. A: Test Lead – High connected to load side of Brkr. C137, wire no. W484-066-20. Test Lead – Low connected to ground. Entire circuit characterized from Brkr. C137 to heater A21 connection.

Circuit AFCB7

Description: First Officers Window Heat 4 and 5
Device Code: AFCB7_1ST_OF_WDW_HTR
Drawing: E30-41-01
Test Area: Panel P6, Breaker C152
Test Set Up:

- Breaker C152 – open
- Jumper installed between Pin 3 of D4082J and Pin 15 of D4082P

Testing configurations associated with this circuit:: 1, Test Cfg. A

Test Cfg. A: Test Lead – High connected to load side of Brkr. C152, wire no. W484-007-20. Test Lead – Low connected to ground. Entire circuit characterized from Brkr. C152 to S173, which may have been open due to high temperature of local environment.

Circuit AFCB8

Description: Project Power (phase A of 400/60 Hz converter)
Device Code: AFCB8_PROJECT_POWER
Drawing: 9854014
Test Area: Project Power J-Box, Breaker CB5
Test Set Up:

- Breaker CB5 – open
- K3 contact jumpered
- PS1 removed

Testing configurations associated with this circuit:: 1, Test Cfg. A

Test Cfg. A: High connected to load side of Brkr. CB5, wire XP36B10A. Test Lead – Low connected to ground. Entire circuit characterized from Brkr. CB5 to PS1 connector.

ECAD SYSTEM 1100 Version 7.00 DATA CHART

File Set: C:\ECAD\DATA\FAM48

CIRCUIT IDENTIFICATION

DEVICE CODE	: AFCB1_L_INBD_LNDG_LT	TEST AREA	: BREAKER PANEL P18		
DESCRIPTION	: LEFT INBOARD LANDING LIGHT	TERMINATION	: BREAKER	ID CODE : C251	
DEVICE TYPE	: CBL	HIGH TEST POINT	: W508	ID CODE : 136-20	PIN :
CONFIGURATION	: A	LOW TEST POINT	: GROUND	ID CODE :	PIN :
		COMMENTS	: LEAD TO GROUND		

OPERATOR IDENTIFICATION

OP LAST NAME	:	FIRST NAME	:
AS LAST NAME	:	FIRST NAME	:
MO#	:		

U MEASUREMENT UNDEFINED
L INDUCTANCE/QUALITY (H/UNITY)
C CAPACITANCE/DISSIPATION (F/UNITY)

TEST	TEST	AC + DC	DC RESISTANCE	AC RESISTANCE	REACTANCE		
DATE	TIME	VOLTAGE	(OHMS)	1 kHz (OHMS)	1 kHz (OHMS)		1kHz
R 08/27/2001	10:40	2.61	> 500.00 k	5.91 k	-50.21 k	C	3.17 n / 117.70 n
T 08/27/2001	10:40	2.61	> 500.00 k	5.91 k	-50.21 k	C	3.17 n / 117.70 n

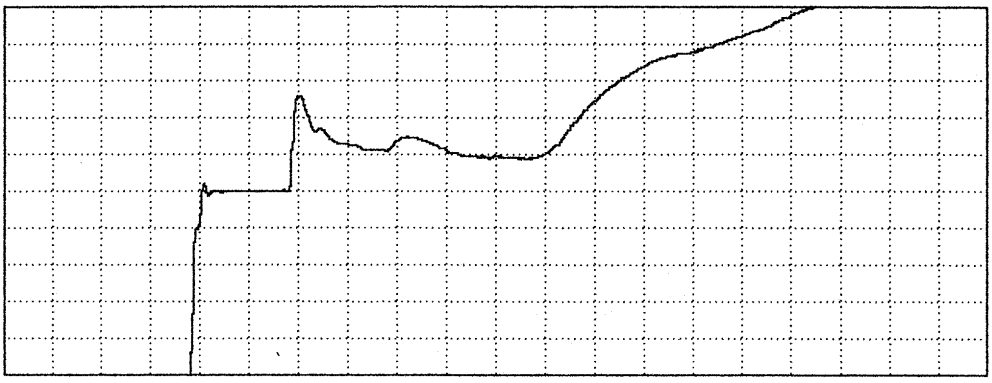
INSULATION RESISTANCE DATA

IR TEST	IR (OHMS)		DURATION	POLARIZATION
VOLTAGE	FIRST	FINAL	(SECONDS)	RATIO
R 100	302.21 M	481.57 M	60	1.77
T 100	302.21 M	481.57 M	60	1.77

LEGEND

(T) = TEST T = tera G = giga M = mega k = kilo
(R) = REFERENCE m = milli u = micro n = nano p = pico

TDR Signature(s)



Horizontal (feet) / Vertical (Rho = .2/div)

TEST (SOLID)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

REFERENCE (DASHED)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

1A

ECAD SYSTEM 1100 Version 7.00 DATA CHART

File Set: C:\ECAD\DATA\FAM40

CIRCUIT IDENTIFICATION

DEVICE CODE	: AFCB2_OSCIL_NAV_LT	TEST AREA	: BREAKER PANEL P18		
DESCRIPTION	: OSCILLATING NAVIGATION LIGHTS	TERMINATION	: BREAKER	ID CODE : C258	
DEVICE TYPE	: CBL	HIGH TEST POINT	: W508	ID CODE : 110-20	PIN :
CONFIGURATION	: A	LOW TEST POINT	: GROUND	ID CODE :	PIN :
		COMMENTS	: LEAD TO GROUND, ENTIRE CIRCUIT		

OPERATOR IDENTIFICATION

OP LAST NAME	:	FIRST NAME	:
AS LAST NAME	:	FIRST NAME	:
MOH	:		

U MEASUREMENT UNDEFINED
L INDUCTANCE/QUALITY (H/UNITY)
C CAPACITANCE/DISSIPATION (F/UNITY)

TEST DATE	TEST TIME	AC + DC VOLTAGE	DC RESISTANCE (OHMS)	AC RESISTANCE 1 kHz (OHMS)	REACTANCE 1 kHz (OHMS)		1kHz
R 08/27/2001	12:41	1.20	> 500.00 k	1.27 k	-11.43 k	C	13.93 n / 111.21 n
T 08/27/2001	12:41	1.20	> 500.00 k	1.27 k	-11.43 k	C	13.93 n / 111.21 n

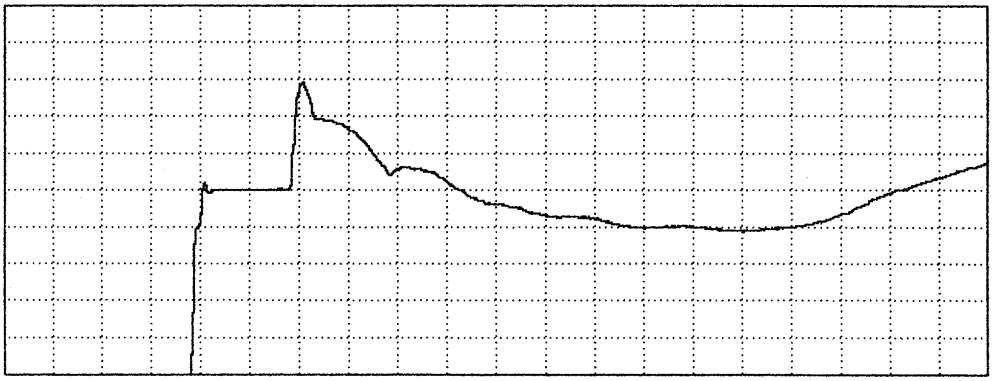
INSULATION RESISTANCE DATA

	IR TEST VOLTAGE	IR (OHMS) FIRST	IR (OHMS) FINAL	DURATION (SECONDS)	POLARIZATION RATIO
R	100	52.86 M	55.99 M	60	998.20 m
T	100	52.86 M	55.99 M	60	998.20 m

LEGEND

(T) = TEST (R) = REFERENCE
T = tera G = giga M = mega k = kilo
m = milli u = micro n = nano p = pico

TDR Signature(s)



Horizontal (feet) / Vertical (Rho = .2/div)

TEST (SOLID)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

REFERENCE (DASHED)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

2A

ECAD SYSTEM 1100 Version 7.00 DATA CHART

File Set: C:\ECAD\DATA\FAM48

CIRCUIT IDENTIFICATION

DEVICE CODE	: AFCB2_OSCIL_NAV_LT	TEST AREA	: BREAKER PANEL P18		
DESCRIPTION	: OSCILLATING NAVIGATION LIGHTS	TERMINATION	: BREAKER	ID CODE : C258	
DEVICE TYPE	: CBL	HIGH TEST POINT	: W376	ID CODE : 002-20	PIN :
CONFIGURATION	: B	LOW TEST POINT	: GROUND	ID CODE :	PIN :
		COMMENTS	: LEAD TO GROUND, CONNECTOR D1470J, STN 259		

OPERATOR IDENTIFICATION

OP LAST NAME	:	FIRST NAME	:
AS LAST NAME	:	FIRST NAME	:
MOH	:		

U MEASUREMENT UNDEFINED
L INDUCTANCE/QUALITY (H/UNITY)
C CAPACITANCE/DISSIPATION (F/UNITY)

TEST	TEST	AC + DC	DC RESISTANCE	AC RESISTANCE	REACTANCE		
DATE	TIME	VOLTAGE	(OHMS)	1 kHz (OHMS)	1 kHz (OHMS)		1kHz
R 08/27/2001	15:23	1.74	> 500.00 k	2.94 k	-40.72 k	C	3.91 n / 72.21 n
T 08/27/2001	15:23	1.74	> 500.00 k	2.94 k	-40.72 k	C	3.91 n / 72.21 n

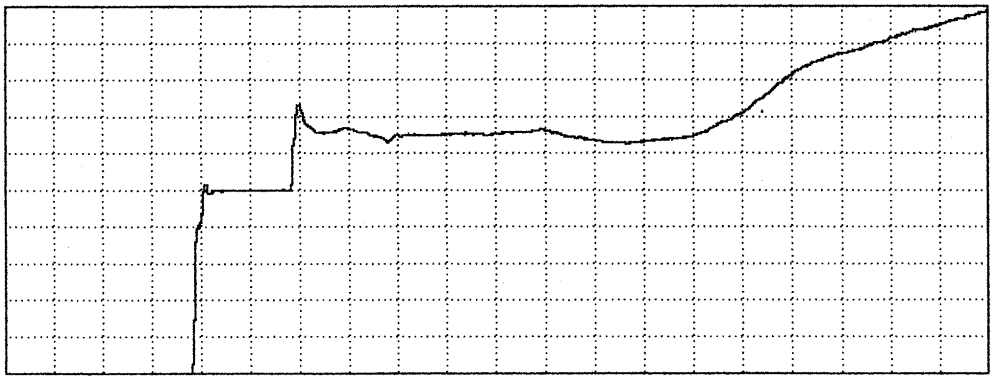
INSULATION RESISTANCE DATA

IR TEST	IR (OHMS)		DURATION	POLARIZATION
VOLTAGE	FIRST	FINAL	(SECONDS)	RATIO
R 100	156.88 M	179.98 M	60	1.08
T 100	156.88 M	179.98 M	60	1.08

LEGEND

(T) = TEST T = tera G = giga M = mega k = kilo
(R) = REFERENCE m = milli u = micro n = nano p = pico

TDR Signature(s)



Horizontal (feet) / Vertical (Rho = .2/div)

TEST (SOLID)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

REFERENCE (DASHED)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

2B

ECAD SYSTEM 1100 Version 7.00 DATA CHART

File Set: C:\ECAD\DATA\FAM10

CIRCUIT IDENTIFICATION

DEVICE CODE	: AFCB2_OSCIL_NAV_LT	TEST AREA	: BREAKER PANEL P18		
DESCRIPTION	: OSCILLATING NAVIGATION LIGHTS	TERMINATION	: BREAKER	ID CODE : C258	
DEVICE TYPE	: CBL	HIGH TEST POINT	: W508	ID CODE : 100-20	PIN :
CONFIGURATION	: C	LOW TEST POINT	: GROUND	ID CODE :	PIN :
		COMMENTS	: LEAD TO GROUND, TO CONN D4310P		

OPERATOR IDENTIFICATION

OP LAST NAME	: SERENA	FIRST NAME	: KEN
AS LAST NAME	:	FIRST NAME	:
MOD	:		

U MEASUREMENT UNDEFINED
L INDUCTANCE/QUALITY (H/UNITY)
C CAPACITANCE/DISSIPATION (F/UNITY)

TEST DATE	TEST TIME	DC + DC VOLTAGE	DC RESISTANCE (OHMS)	AC RESISTANCE 1 kHz (OHMS)	REACTANCE 1 kHz (OHMS)		1kHz
R 08/28/2001	08:30	1.90	> 500.00 k	8.21 k	-142.03 k	C	1.12 n / 57.80 n
T 08/28/2001	08:30	1.90	> 500.00 k	8.21 k	-142.03 k	C	1.12 n / 57.80 n

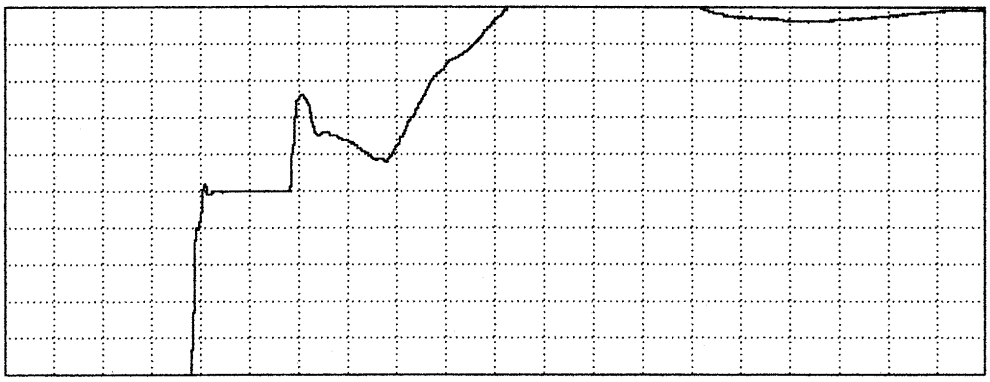
INSULATION RESISTANCE DATA

	IR TEST VOLTAGE	IR (OHMS) FIRST	IR (OHMS) FINAL	DURATION (SECONDS)	POLARIZATION RATIO
R	100	86.03 M	74.75 M	60	896.55 m
T	100	86.03 M	74.75 M	60	896.55 m

LEGEND

(T) = TEST (R) = REFERENCE
T = tera G = giga M = mega k = kilo
m = milli u = micro n = nano p = pico

TDR Signature(s)



Horizontal (feet) / Vertical (Rho = .2/div)

TEST (SOLID)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

REFERENCE (DASHED)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

2C

ECAD SYSTEM 1100 Version 7.00 DATA CHART

File Set: C:\ECAD\DATA\FAM0

CIRCUIT IDENTIFICATION

DEVICE CODE	: AFCB2_OSCIL_NAV_LT	TEST AREA	: BREAKER PANEL P18		
DESCRIPTION	: OSCILLATING NAVIGATION LIGHTS	TERMINATION	: CONNECTOR	ID CODE : D4310P	
DEVICE TYPE	: CBL	HIGH TEST POINT	: W436	ID CODE : 057-20	PIN :
CONFIGURATION	: D	LOW TEST POINT	: GROUND	ID CODE :	PIN :
		COMMENTS	: LEAD TO GROUND, TO BRKR 258		

OPERATOR IDENTIFICATION

OP LAST NAME	:	FIRST NAME	:
AS LAST NAME	:	FIRST NAME	:
MO#	:		

U MEASUREMENT UNDEFINED
L INDUCTANCE/QUALITY (H/UNITY)
C CAPACITANCE/DISSIPATION (F/UNITY)

TEST	TEST	AC + DC	DC RESISTANCE	AC RESISTANCE	REACTANCE		
DATE	TIME	VOLTAGE	(OHMS)	1 kHz (OHMS)	1 kHz (OHMS)		1kHz
R 08/27/2001	15:56	2.81	> 500.00 k	6.55 k	-140.44 k	C	1.13 n / 46.67 n
T 08/27/2001	15:56	2.81	> 500.00 k	6.55 k	-140.44 k	C	1.13 n / 46.67 n

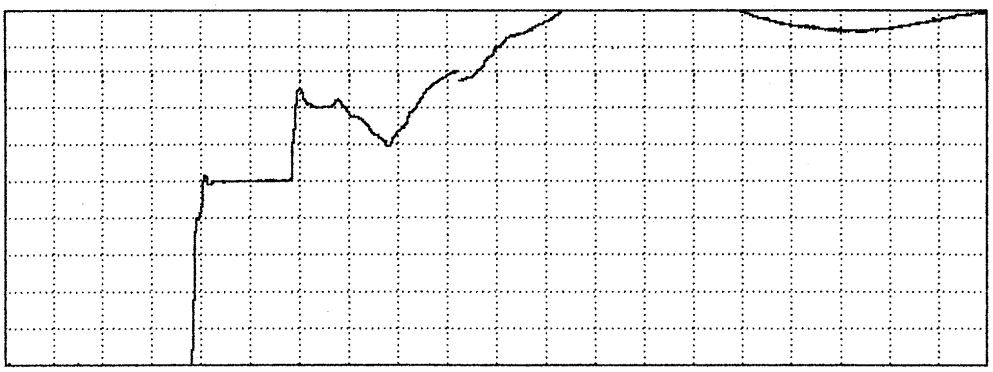
INSULATION RESISTANCE DATA

	IR TEST VOLTAGE	IR (OHMS) FIRST	IR (OHMS) FINAL	DURATION (SECONDS)	POLARIZATION RATIO
R	100	101.99 M	85.19 M	60	870.66 m
T	100	101.99 M	85.19 M	60	870.66 m

LEGEND

(I) = TEST (R) = REFERENCE
T = tera G = giga M = mega k = kilo
m = milli u = micro n = nano p = pico

TDR Signature(s)



Horizontal (feet) / Vertical (Rho = .2/div)

TEST (SOLID)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

REFERENCE (DASHED)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

2D

ECAD SYSTEM 1100 Version 7.00 DATA CHART

File Set: C:\ECAD\DATA\FAM40

CIRCUIT IDENTIFICATION

DEVICE CODE	: AFCB2_OSCIL_NAV_LT	TEST AREA	: BREAKER PANEL P18		
DESCRIPTION	: OSCILLATING NAVIGATION LIGHTS	TERMINATION	: CONNECTOR	ID CODE : D4310P	
DEVICE TYPE	: CBL	HIGH TEST POINT	: W436	ID CODE : 045-22	PIN :
CONFIGURATION	: E	LOW TEST POINT	: GROUND	ID CODE :	PIN :
		COMMENTS	: LEAD TO GROUND, TO BRKR 258		

OPERATOR IDENTIFICATION

OP LAST NAME	:	FIRST NAME	:
AS LAST NAME	:	FIRST NAME	:
MO#	:		

U MEASUREMENT UNDEFINED
L INDUCTANCE/QUALITY (H/UNITY)
C CAPACITANCE/DISSIPATION (F/UNITY)

	TEST DATE	TEST TIME	AC + DC VOLTAGE	DC RESISTANCE (OHMS)	AC RESISTANCE 1 kHz (OHMS)	REACTANCE 1 kHz (OHMS)		1kHz
R	08/27/2001	16:22	2.68	> 500.00 k	6.57 k	-140.76 k	C	1.13 n / 46.70 m
T	08/27/2001	16:22	2.68	> 500.00 k	6.57 k	-140.76 k	C	1.13 n / 46.70 m

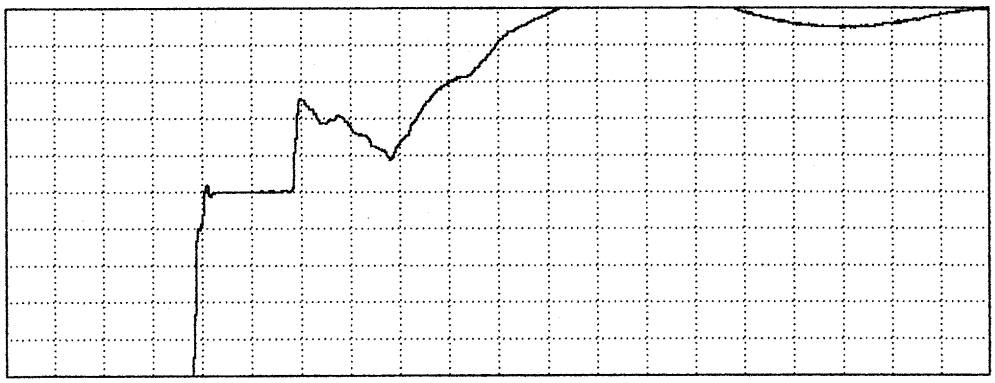
INSULATION RESISTANCE DATA

	IR TEST VOLTAGE	IR (OHMS) FIRST	IR (OHMS) FINAL	DURATION (SECONDS)	POLARIZATION RATIO
R	100	85.31 M	75.30 M	60	917.32 m
T	100	85.31 M	75.30 M	60	917.32 m

LEGEND

(T) = TEST (R) = REFERENCE
T = tera G = giga M = mega k = kilo
m = milli u = micro n = nano p = pico

TDR Signature(s)



Horizontal (feet) / Vertical (Rho = .2/div)

TEST (SOLID)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

REFERENCE (DASHED)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

2E

ECAD SYSTEM 1100 Version 7.00 DATA CHART

File Set: C:\ECAD\DATA\FAM40

CIRCUIT IDENTIFICATION

DEVICE CODE	: AFCB2_OSCIL_NAV_LT	TEST AREA	: BREAKER PANEL P18		
DESCRIPTION	: OSCILLATING NAVIGATION LIGHTS	TERMINATION	: CONNECTOR	ID CODE : 04310P	
DEVICE TYPE	: CBL	HIGH TEST POINT	: W068	ID CODE : 013-22	PIN :
CONFIGURATION	: F	LOW TEST POINT	: GROUND	ID CODE :	PIN :
		COMMENTS	: LEAD TO GROUND, TO RIGHT NAV GREEN LIGHT		

OPERATOR IDENTIFICATION

OP LAST NAME	:	FIRST NAME	:
AS LAST NAME	:	FIRST NAME	:
MO#	:		

U MEASUREMENT UNDEFINED
L INDUCTANCE/QUALITY (H/UNITY)
C CAPACITANCE/DISSIPATION (F/UNITY)

TEST	TEST	AC + DC	DC RESISTANCE	AC RESISTANCE	REACTANCE		
DATE	TIME	VOLTAGE	(OHMS)	1 kHz (OHMS)	1 kHz (OHMS)		1kHz
R 08/27/2001	16:29	1.74	> 500.00 k	4.58 k	-34.67 k	C	4.59 n / 132.03 m
T 08/27/2001	16:29	1.74	> 500.00 k	4.58 k	-34.67 k	C	4.59 n / 132.03 m

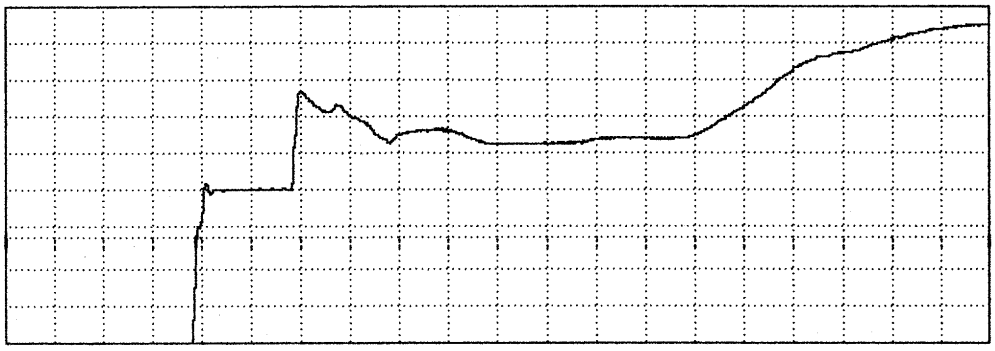
INSULATION RESISTANCE DATA

	IR TEST VOLTAGE	IR (OHMS) FIRST	IR (OHMS) FINAL	DURATION (SECONDS)	POLARIZATION RATIO
R	100	375.35 M	520.69 M	60	1.17
T	100	375.35 M	520.69 M	60	1.17

LEGEND

(T) = TEST (R) = REFERENCE T = tera G = giga M = mega k = kilo n = milli u = micro n = nano p = pico

TDR Signature(s)



Horizontal (feet) / Vertical (Rho = .2/div)

TEST (SOLID)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

REFERENCE (DASHED)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

2F

ECAD SYSTEM 1100 Version 7.00 DATA CHART

File Set: C:\ECAD\DATA\FAM40

CIRCUIT IDENTIFICATION

DEVICE CODE	: AFCB2_OSCIL_NAV_LT	TEST AREA	: BREAKER PANEL P18		
DESCRIPTION	: OSCILLATING NAVIGATION LIGHTS	TERMINATION	: CONNECTOR	ID CODE : D4310P	
DEVICE TYPE	: CBL	HIGH TEST POINT	: WD68	ID CODE : 017-22	PIN :
CONFIGURATION	: G	LOW TEST POINT	: GROUND	ID CODE :	PIN :
		COMMENTS	: LEAD TO GROUND, TO LEFT NAV RED LIGHT		

OPERATOR IDENTIFICATION

OP LAST NAME	:	FIRST NAME	:
AS LAST NAME	:	FIRST NAME	:
MO#	:		

U MEASUREMENT UNDEFINED
L INDUCTANCE/QUALITY (H/UNITY)
C CAPACITANCE/DISSIPATION (F/UNITY)

TEST	TEST	AC + DC	DC RESISTANCE	AC RESISTANCE	REACTANCE		
DATE	TIME	VOLTAGE	(OHMS)	1 kHz (OHMS)	1 kHz (OHMS)		1kHz
R 08/27/2001	16:51	1.90	> 500.00 k	4.23 k	-35.49 k	C	4.48 n / 119.21 n
T 08/27/2001	16:51	1.90	> 500.00 k	4.23 k	-35.49 k	C	4.48 n / 119.21 n

INSULATION RESISTANCE DATA

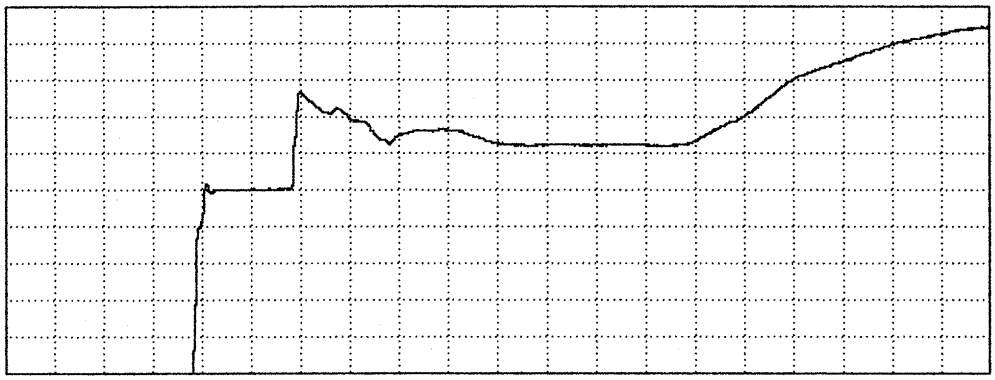
IR TEST	IR (OHMS)		DURATION	POLARIZATION
VOLTAGE	FIRST	FINAL	(SECONDS)	RATIO
R 100	1.09 G	3.44 G	60	1.82
T 100	1.06 G	3.27 G	60	1.85

LEGEND

(T) = TEST
(R) = REFERENCE

T = tera G = giga M = mega k = kilo
n = milli u = micro n = nano p = pico

TDR Signature(s)



Horizontal (feet) / Vertical (Rho = .2/div)

TEST (SOLID)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

REFERENCE (DASHED)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

26

ECAD SYSTEM 1100 Version 7.00 DATA CHART

File Set: C:\ECAD\DATA\FAM40

CIRCUIT IDENTIFICATION

DEVICE CODE	: AFCB3_WNDW_LITE_LEFT	TEST AREA	: BREAKER PANEL P10		
DESCRIPTION	: WINDOW LIGHT LEFT SIDE	TERMINATION	: BREAKER	ID CODE : C1023	
DEVICE TYPE	: CBL	HIGH TEST POINT	: W508	ID CODE : 179-10	PIN :
CONFIGURATION	: A	LOW TEST POINT	: GROUND	ID CODE :	PIN :
		COMMENTS	: LEAD TO GROUND, ENTIRE CIRCUIT (LOADS CONNECTED)		

OPERATOR IDENTIFICATION

OP LAST NAME	: SERENA	FIRST NAME	: KEN
AS LAST NAME	:	FIRST NAME	:
MOH	:		

U MEASUREMENT UNDEFINED
L INDUCTANCE/QUALITY (H/UNITY)
C CAPACITANCE/DISSIPATION (F/UNITY)

TEST	TEST	AC + DC	DC RESISTANCE	AC RESISTANCE	REACTANCE		
DATE	TIME	VOLTAGE	(OHMS)	1 kHz (OHMS)	1 kHz (OHMS)		1kHz
R 08/28/2001	10:42	0.61 m	7.08	12.10	-16.56	C	9.61 u / 730.47 n
T 08/28/2001	10:42	0.61 m	7.08	12.10	-16.56	C	9.61 u / 730.47 n

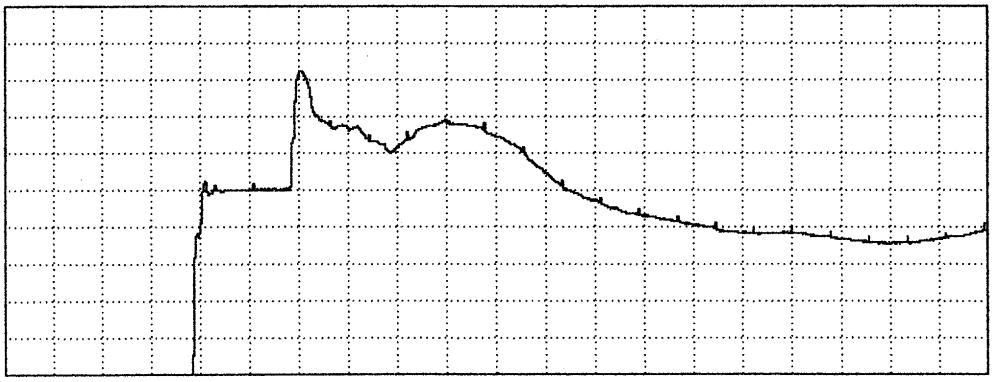
INSULATION RESISTANCE DATA

IR TEST	IR (OHMS)		DURATION	POLARIZATION
VOLTAGE	FIRST	FINAL	(SECONDS)	RATIO
R 0	0	0	0	0
T 0	0	0	0	0

LEGEND

(T) = TEST (R) = REFERENCE
T = tera G = giga M = mega k = kilo
m = milli u = micro n = nano p = pico

TDR Signature(s)



Horizontal (feet) / Vertical (Rho = .2/div)

TEST (SOLID)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

REFERENCE (DASHED)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

3A

ECAD SYSTEM 1100 Version 7.00 DATA CHART

File Set: C:\ECAD\DATA\FAM40

CIRCUIT IDENTIFICATION

DEVICE CODE	: AFCB3_WNDW_LITE_LEFT	TEST AREA	: BREAKER PANEL P18		
DESCRIPTION	: WINDOW LIGHT LEFT SIDE	TERMINATION	: CONNECTOR	ID CODE : D4878J	
DEVICE TYPE	: CBL	HIGH TEST POINT	: W306	ID CODE : 684-20	PIN :
CONFIGURATION	: B	LOW TEST POINT	: GROUND	ID CODE :	PIN :
		COMMENTS	: LEAD TO GROUND, TEST FROM CONNECTOR TO LOAD		

OPERATOR IDENTIFICATION

OP LAST NAME	: SERENA	FIRST NAME	: KEN
AS LAST NAME	:	FIRST NAME	:
MO#	:		

B MEASUREMENT UNDEFINED
L INDUCTANCE/QUALITY (H/UNITY)
C CAPACITANCE/DISSIPATION (F/UNITY)

TEST	TEST	AC + DC	DC RESISTANCE	DC RESISTANCE	REACTANCE		
DATE	TIME	VOLTAGE	(OHMS)	1 kHz (OHMS)	1 kHz (OHMS)		1kHz
R 08/28/2001	09:59	0.59 m	4.92	14.17	-29.93	C	5.32 u / 473.47 n
T 08/28/2001	09:59	0.59 m	4.92	14.17	-29.93	C	5.32 u / 473.47 n

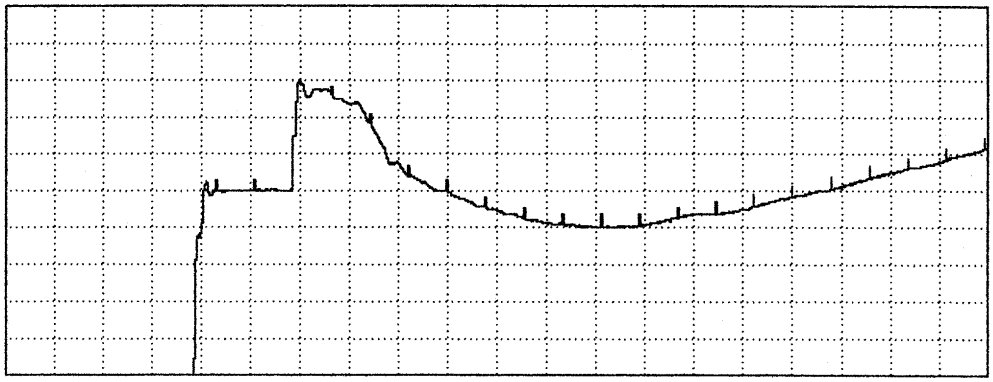
INSULATION RESISTANCE DATA

	IR TEST	IR (OHMS)		DURATION	POLARIZATION
	VOLTAGE	FIRST	FINAL	(SECONDS)	RATIO
R	0	0	0	0	0
T	0	0	0	0	0

LEGEND

(I) = TEST (R) = REFERENCE
T = tera G = giga M = mega k = kilo
m = milli u = micro n = nano p = pico

TDR Signature(s)



Horizontal (feet) / Vertical (Rho = .2/div)

TEST (SOLID)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

REFERENCE (BASHED)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

3B

ECAD SYSTEM 1100 Version 7.00 DATA CHART

File Set: C:\ECAD\DATA\FAM40

CIRCUIT IDENTIFICATION

DEVICE CODE	: AFCB3_WNDW_LITE_LEFT	TEST AREA	: BREAKER PANEL P18		
DESCRIPTION	: WINDOW LIGHT LEFT SIDE	TERMINATION	: CONNECTOR	ID CODE : D4878J	
DEVICE TYPE	: CBL	HIGH TEST POINT	: W306	ID CODE : 685-20	PIN :
CONFIGURATION	: C	LOW TEST POINT	: GROUND	ID CODE :	PIN :
		COMMENTS	: LEAD TO GROUND, TEST FROM CONNECTOR TO LOAD		

OPERATOR IDENTIFICATION

OP LAST NAME	: SERENA	FIRST NAME	: KEN
AS LAST NAME	:	FIRST NAME	:
MO#	:		

U MEASUREMENT UNDEFINED
L INDUCTANCE/QUALITY (H/UNITY)
C CAPACITANCE/DISSIPATION (F/UNITY)

TEST	TEST	AC + DC	DC RESISTANCE	AC RESISTANCE	REACTANCE		
DATE	TIME	VOLTAGE	(OHMS)	1 kHz (OHMS)	1 kHz (OHMS)		1kHz
R 08/28/2001	10:21	0.57 n	6.41	16.80	-36.80	C	4.32 u / 456.55 n
T 08/28/2001	10:21	0.57 n	6.41	16.80	-36.80	C	4.32 u / 456.55 n

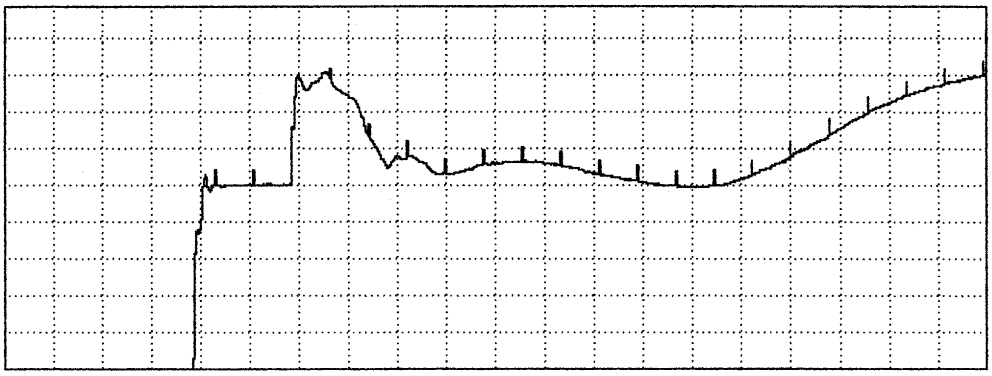
INSULATION RESISTANCE DATA

	IR TEST VOLTAGE	IR (OHMS) FIRST	IR (OHMS) FINAL	DURATION (SECONDS)	POLARIZATION RATIO
R	0	0	0	0	0
T	0	0	0	0	0

LEGEND

(T) = TEST (R) = REFERENCE
T = tera G = giga M = mega k = kilo
n = milli u = micro n = nano p = pico

TDR Signature(s)



Horizontal (feet) / Vertical (Rho = .2/div)

TEST (SOLID)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

REFERENCE (DASHED)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

3c

ECAD SYSTEM 1100 Version 7.00 DATA CHART

File Set: C:\ECAD\DATA\FAM40

CIRCUIT IDENTIFICATION

DEVICE CODE	: AFCB4_PSGR_CEIL_LT_L	TEST AREA	: BREAKER PANEL P18		
DESCRIPTION	: PASSENGER CEILING LIGHTS LEFT	TERMINATION	: BREAKER	ID CODE : C273	
DEVICE TYPE	: CBL	HIGH TEST POINT	: W508	ID CODE : 671-16	PIN :
CONFIGURATION	: A	LOW TEST POINT	: GROUND	ID CODE :	PIN :
		COMMENTS	: LEAD TO GROUND, ENTIRE CIRCUIT (WITH LOADS CONN)		

OPERATOR IDENTIFICATION

OP LAST NAME	: SERENA	FIRST NAME	: KEN
AS LAST NAME	:	FIRST NAME	:
MO#	:		

U MEASUREMENT UNDEFINED
L INDUCTANCE/QUALITY (H/UNITY)
C CAPACITANCE/DISSIPATION (F/UNITY)

TEST DATE	TEST TIME	AC + DC VOLTAGE	DC RESISTANCE (OHMS)	AC RESISTANCE 1 kHz (OHMS)	REACTANCE 1 kHz (OHMS)		1kHz
R 08/28/2001	11:44	0.58 m	9.69	227.61	215.27	L	34.26 m / 945.79 m
T 08/28/2001	11:44	0.58 m	9.69	227.61	215.27	L	34.26 m / 945.79 m

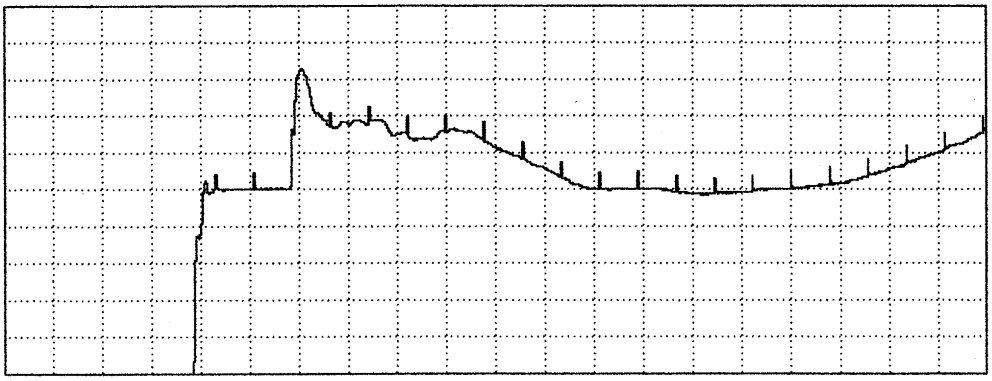
INSULATION RESISTANCE DATA

	IR TEST VOLTAGE	IR (OHMS) FIRST	IR (OHMS) FINAL	DURATION (SECONDS)	POLARIZATION RATIO
R	0	0	0	0	0
T	0	0	0	0	0

LEGEND

(T) = TEST, (R) = REFERENCE
T = tera, G = giga, M = mega, k = kilo
m = milli, u = micro, n = nano, p = pico

TDR Signature(s)



Horizontal (feet) / Vertical (Rho = .2/div)

TEST (SOLID)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

REFERENCE (DASHED)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

4A

ECAD SYSTEM 1100 Version 7.00 DATA CHART

File Set: C:\ECAD\DATA\FAM40

CIRCUIT IDENTIFICATION

DEVICE CODE	: AFCB4_PSGR_CEIL_LT_L	TEST AREA	: BREAKER PANEL P18		
DESCRIPTION	: PASSENGER CEILING LIGHTS LEFT	TERMINATION	: BREAKER	ID CODE : C273	
DEVICE TYPE	: CBL	HIGH TEST POINT	: W508	ID CODE : 671-16	PIN :
CONFIGURATION	: B	LOW TEST POINT	: GROUND	ID CODE :	PIN :
		COMMENTS	: LEAD TO GROUND, BRKR TO CONN. D4490J (NO LOADS)		

OPERATOR IDENTIFICATION

OP LAST NAME	: SERENA	FIRST NAME	: KEN
AS LAST NAME	:	FIRST NAME	:
MO#	:		

U MEASUREMENT UNDEFINED
L INDUCTANCE/QUALITY (H/UNITY)
C CAPACITANCE/DISSIPATION (F/UNITY)

TEST DATE	TEST TIME	AC + DC VOLTAGE	DC RESISTANCE (OHMS)	DC RESISTANCE 1 kHz (OHMS)	REACTANCE 1 kHz (OHMS)		1kHz
R 08/28/2001	13:26	746.90 m	> 500.00 k	5.46 k	-124.95 k	C	1.27 n / 43.66 m
T 08/28/2001	13:26	746.90 m	> 500.00 k	5.46 k	-124.95 k	C	1.27 n / 43.66 m

INSULATION RESISTANCE DATA

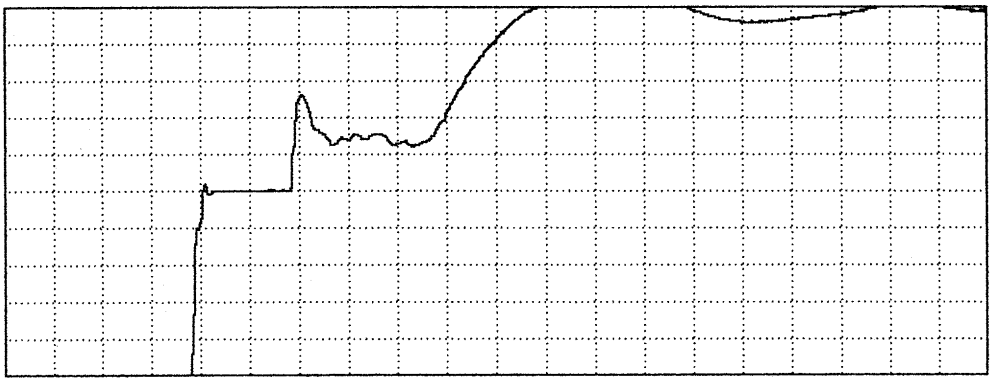
IR TEST VOLTAGE		IR (OHMS) FIRST	IR (OHMS) FINAL	DURATION (SECONDS)	POLARIZATION RATIO
R	100	24.65 M	27.58 M	60	1.09
T	100	24.65 M	27.58 M	60	1.09

LEGEND

(T) = TEST (R) = REFERENCE

T = tera G = giga M = mega k = kilo
m = milli u = micro n = nano p = pico

TDR Signature(s)



Horizontal (feet) / Vertical (Rho = .2/div)

TEST (SOLID)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

REFERENCE (DASHED)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

4B

ECAD SYSTEM 1100 Version 7.00 DATA CHART

File Set: C:\ECAD\DATA\FAM40

CIRCUIT IDENTIFICATION

DEVICE CODE	: AFCB5_DME_NO_2	TEST AREA	: BREAKER PANEL P18		
DESCRIPTION	: DISTANCE MEAS. EQUIPMENT NO.2	TERMINATION	: BREAKER	ID CODE : C73	
DEVICE TYPE	: CBL	HIGH TEST POINT	: W033	ID CODE : 099-22	PIN :
CONFIGURATION	: A	LOW TEST POINT	: GROUND	ID CODE :	PIN :
		COMMENTS	: LEAD TO GROUND, BRKR TO OPEN RELAY CONTACT		

OPERATOR IDENTIFICATION

OP LAST NAME	: SERENA	FIRST NAME	: KEN
AS LAST NAME	:	FIRST NAME	:
MO#	:		

U MEASUREMENT UNDEFINED
L INDUCTANCE/QUALITY (H/UNITY)
C CAPACITANCE/DISSIPATION (F/UNITY)

TEST	TEST	AC + DC	DC RESISTANCE	AC RESISTANCE	REACTANCE		
DATE	TIME	VOLTAGE	(OHMS)	1 kHz (OHMS)	1 kHz (OHMS)		1kHz
R 08/28/2001	13:36	2.95	> 500.00 k	14.90 k	-131.40 k	C	1.21 n / 113.41 n
T 08/28/2001	13:36	2.95	> 500.00 k	14.90 k	-131.40 k	C	1.21 n / 113.41 n

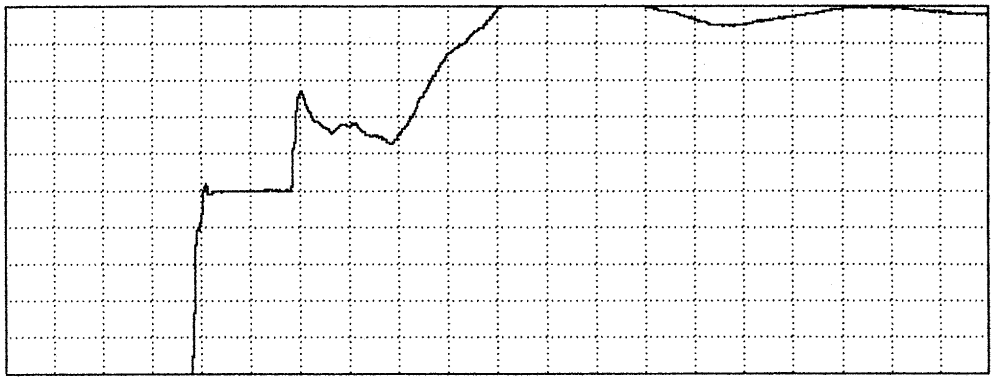
INSULATION RESISTANCE DATA

IR TEST		IR (OHMS)		DURATION	POLARIZATION
	VOLTAGE	FIRST	FINAL	(SECONDS)	RATIO
R	100	1.15 G	1.44 G	60	1.15
T	100	1.15 G	1.44 G	60	1.15

LEGEND

(T) = TEST	T = tera	G = giga	M = mega	k = kilo
(R) = REFERENCE	n = milli	u = micro	n = nano	p = pico

TDR Signature(s)



Horizontal (feet) / Vertical (Rho = .2/div)

TEST (SOLID)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

REFERENCE (DASHED)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

5A

ECAD SYSTEM 1100 Version 7.00 DATA CHART

File Set: C:\ECAD\DATA\FAM0

CIRCUIT IDENTIFICATION

DEVICE CODE	: AFCB6_HTR_PITOT_AUX	TEST AREA	: BREAKER PANEL P18		
DESCRIPTION	: HEATER PITOT AUX.	TERMINATION	: BREAKER	ID CODE : C137	
DEVICE TYPE	: CBL	HIGH TEST POINT	: U484	ID CODE : 066-20	PIN :
CONFIGURATION	: A	LOW TEST POINT	: GROUND	ID CODE :	PIN :
		COMMENTS	: LEAD TO GRND, JUMPER D4080J/4 TO D4080J/10 HTR OUT		

OPERATOR IDENTIFICATION

OP LAST NAME	: SEREMA	FIRST NAME	: KEN
AS LAST NAME	:	FIRST NAME	:
MO#	:		

N MEASUREMENT UNDEFINED
L INDUCTANCE/QUALITY (H/UNITY)
C CAPACITANCE/DISSIPATION (F/UNITY)

TEST	TEST	AC + DC	DC RESISTANCE	AC RESISTANCE	REACTANCE		
DATE	TIME	VOLTAGE	(OHMS)	1 kHz (OHMS)	1 kHz (OHMS)		1kHz
R 08/28/2001	14:15	2.30	> 500.00 k	7.26 k	-100.98 k	C	1.58 n / 71.91 n
T 08/28/2001	14:15	2.30	> 500.00 k	7.26 k	-100.98 k	C	1.58 n / 71.91 n

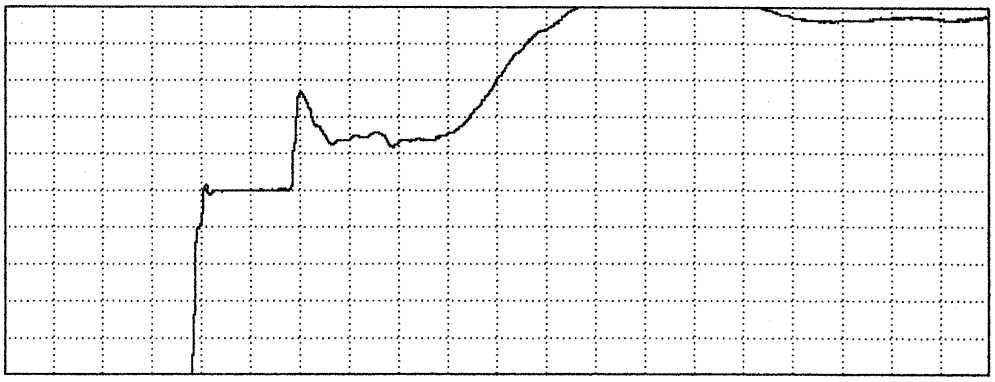
INSULATION RESISTANCE DATA

IR TEST	IR (OHMS)		DURATION	POLARIZATION
VOLTAGE	FIRST	FINAL	(SECONDS)	RATIO
R 100	1.79 G	3.20 G	60	1.36
T 100	1.79 G	3.20 G	60	1.36

LEGEND

(I) = TEST (R) = REFERENCE
T = tera G = giga M = mega k = kilo
m = milli u = micro n = nano p = pico

TDR Signature(s)



Horizontal (feet) / Vertical (Rho = .2/div)

TEST (SOLID)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

REFERENCE (DASHED)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

6A

ECAD SYSTEM 1100 Version 7.00 DATA CHART

File Set: C:\ECAD\DATA\FAM4Q

CIRCUIT IDENTIFICATION

DEVICE CODE	: AFCB8_PROJECT_POWER	TEST AREA	: PROJ PWR J-BOX		
DESCRIPTION	: PROJECT POWER (PHASE A)	TERMINATION	: BREAKER	ID CODE : CB5	
DEVICE TYPE	: CBL	HIGH TEST POINT	: XP36B10A	ID CODE :	PIN :
CONFIGURATION	: A	LOW TEST POINT	: GROUND	ID CODE :	PIN :
		COMMENTS	: LEAD TO GRND, PS1 REMOVED, K3 CONTACT JUMPERED		

OPERATOR IDENTIFICATION

OP LAST NAME	: SEREMA	FIRST NAME	: KEN
AS LAST NAME	:	FIRST NAME	:
MO#	:		

U MEASUREMENT UNDEFINED
L INDUCTANCE/QUALITY (H/UNITY)
C CAPACITANCE/DISSIPATION (F/UNITY)

TEST DATE	TEST TIME	AC + DC VOLTAGE	DC RESISTANCE (OHMS)	AC RESISTANCE 1 kHz (OHMS)	REACTANCE 1 kHz (OHMS)		C 1kHz
R 08/28/2001	16:12	978.83 m	> 500.00 k	-3.49 k	-151.46 k	C	1.05 n / 23.04 m
T 08/28/2001	16:12	978.83 m	> 500.00 k	-3.49 k	-151.46 k	C	1.05 n / 23.04 m

INSULATION RESISTANCE DATA

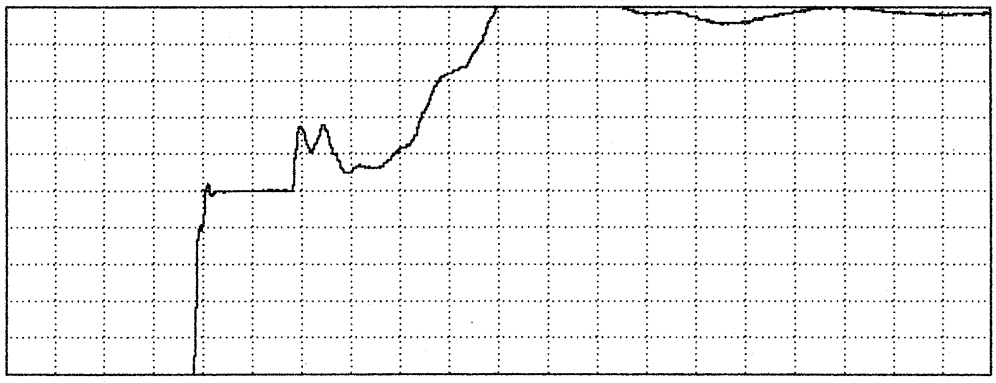
	IR TEST VOLTAGE	IR (OHMS) FIRST	IR (OHMS) FINAL	DURATION (SECONDS)	POLARIZATION RATIO
R	100	37.10 M	38.73 M	60	1.08
T	100	37.10 M	38.73 M	60	1.08

LEGEND

(I) = TEST (R) = REFERENCE

T = tera G = giga M = mega k = kilo
m = milli u = micro n = nano p = pico

TDR Signature(s)



Horizontal (feet) / Vertical (Rho = .2/div)

TEST (SOLID)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

REFERENCE (DASHED)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

7A

ECAD SYSTEM 1100 Version 7.00 DATA CHART

File Set: C:\ECAD\DATA\FAM40

CIRCUIT IDENTIFICATION

DEVICE CODE	: AFCB7_1ST_OF_WDW_HTR	TEST AREA	: BREAKER PANEL P6		
DESCRIPTION	: 1ST OFFICER WINDOW HTRS 4 & 5	TERMINATION	: BREAKER	ID CODE : C152	
DEVICE TYPE	: CBL	HIGH TEST POINT	: W484	ID CODE : 007-20	PIN :
CONFIGURATION	: A	LOW TEST POINT	: GROUND	ID CODE :	PIN :
		COMMENTS	: LEAD TO GRND, JUMPER D4082P/3 TO D4082P/15 HTR OUT		

OPERATOR IDENTIFICATION

OP LAST NAME	: SERENA	FIRST NAME	: KEN
AS LAST NAME	:	FIRST NAME	:
MO#	:		

U MEASUREMENT UNDEFINED
L INDUCTANCE/QUALITY (H/UNITY)
C CAPACITANCE/DISSIPATION (F/UNITY)

TEST DATE	TEST TIME	AC + DC VOLTAGE	DC RESISTANCE (OHMS)	AC RESISTANCE 1 kHz (OHMS)	REACTANCE 1 kHz (OHMS)		1kHz
R 08/28/2001	14:41	2.74	> 500.00 k	7.14 k	-103.59 k	C	1.54 n / 68.89 n
T 08/28/2001	14:41	2.74	> 500.00 k	7.14 k	-103.59 k	C	1.54 n / 68.89 n

INSULATION RESISTANCE DATA

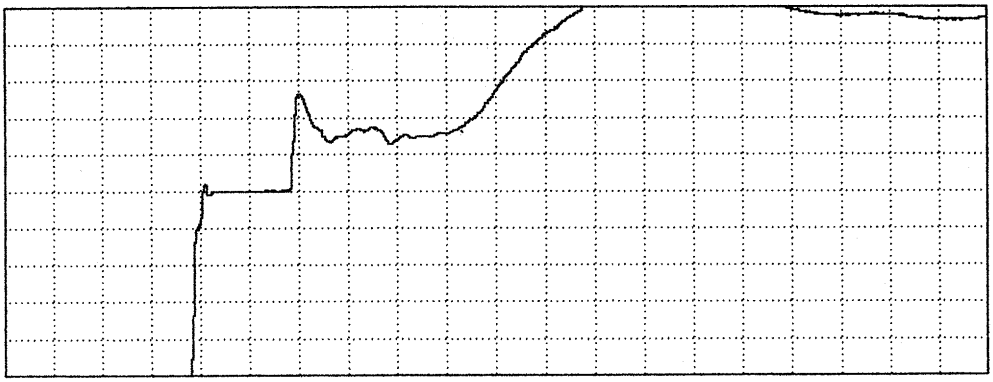
	IR TEST VOLTAGE	IR (OHMS) FIRST	IR (OHMS) FINAL	DURATION (SECONDS)	POLARIZATION RATIO
R	100	644.72 M	806.25 M	60	1.12
T	100	644.72 M	806.25 M	60	1.12

LEGEND

(I) = TEST (R) = REFERENCE

T = tera G = giga M = mega k = kilo
m = milli u = micro n = nano p = pico

TDR Signature(s)



Horizontal (feet) / Vertical (Rho = .2/div)

TEST (SOLID)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

REFERENCE (DASHED)
TIME BASE : 50 nS
FT/DIVISION : Approx 15.0

8A

APPENDIX K—ARC-FAULT CIRCUIT BREAKER WIRING

