Arc Fault Circuit Breaker Development and Implementation

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Outline

- AFCB Program Background
- Pros/Cons of AFCB Installation
- AFCB Implementation Considerations
- Present & Future Arc Fault Protection and Diagnostics Options

AFCB Program Background

- Development contracts awarded Dec 1999
- Eaton Corporation
  - 24 month contract
  - Adapted from 60 Hz Household AFCB
- Hendry Telephone Company
  - 33 month contract
  - Partnered with Texas Instruments/Klixon
  - Adapted From 48 volt DC Arc Detection Patent

AFCB Program Background

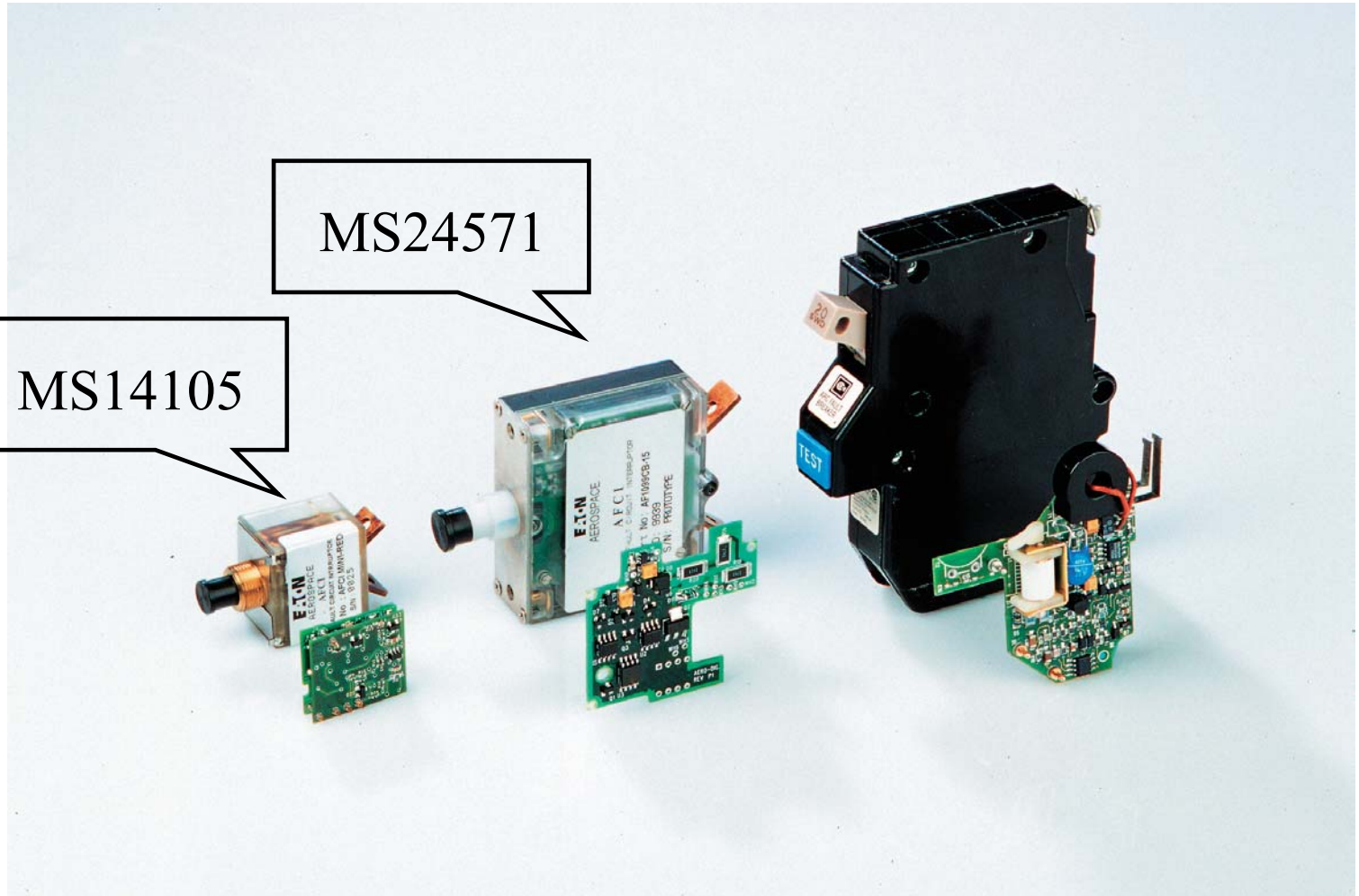
- Deliver 20 MS24571 or smaller AFCB prototypes tested to minimum safety of flight requirements
  - Temperature (-20°C to 71°C)
  - Altitude (0-45,000 feet)
  - Vibration (MIL-STD-810/DO-160)
  - EMI (MIL-STD-461D/DO-160)
  - Electrical (MIL-STD-704A/DO-160)

AFCB Program Status

- Eaton Corporation
  - 20 units delivered for flight testing on FAA Boeing 727 and Navy Boeing C-9
  - Navy flight testing began 24 August, 2001
  - FAA flight testing began 10 September, 2001
- Hendry Telephone Company/Texas Instruments
  - Safety of flight laboratory tests February 2002
  - Flight test in April 2002

AFCB Development

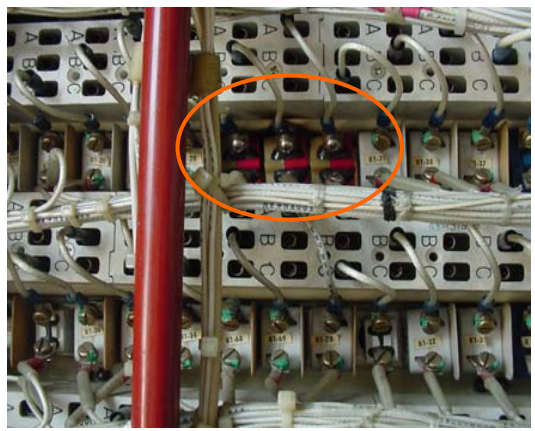
Eaton Corporation



AFCB Development

Hendry/Texas Instruments

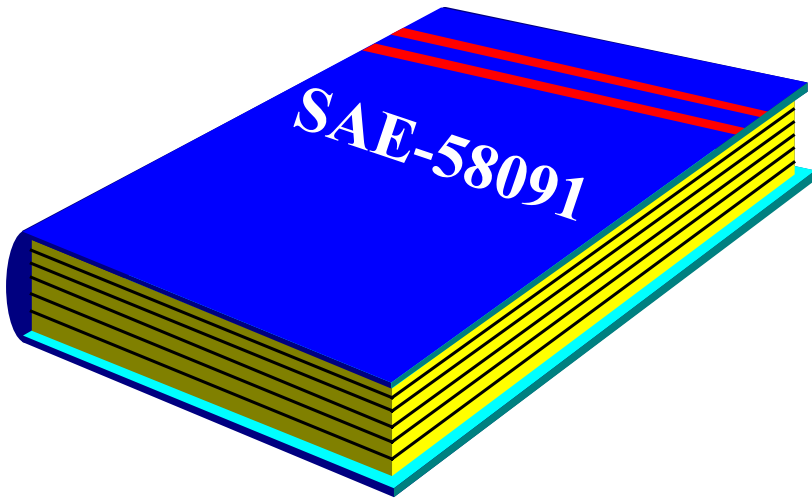
AFCB Installation on Navy C-9 Aircraft (VR-56)



First Navy Flight of Eaton AFCB on August 24, 2001

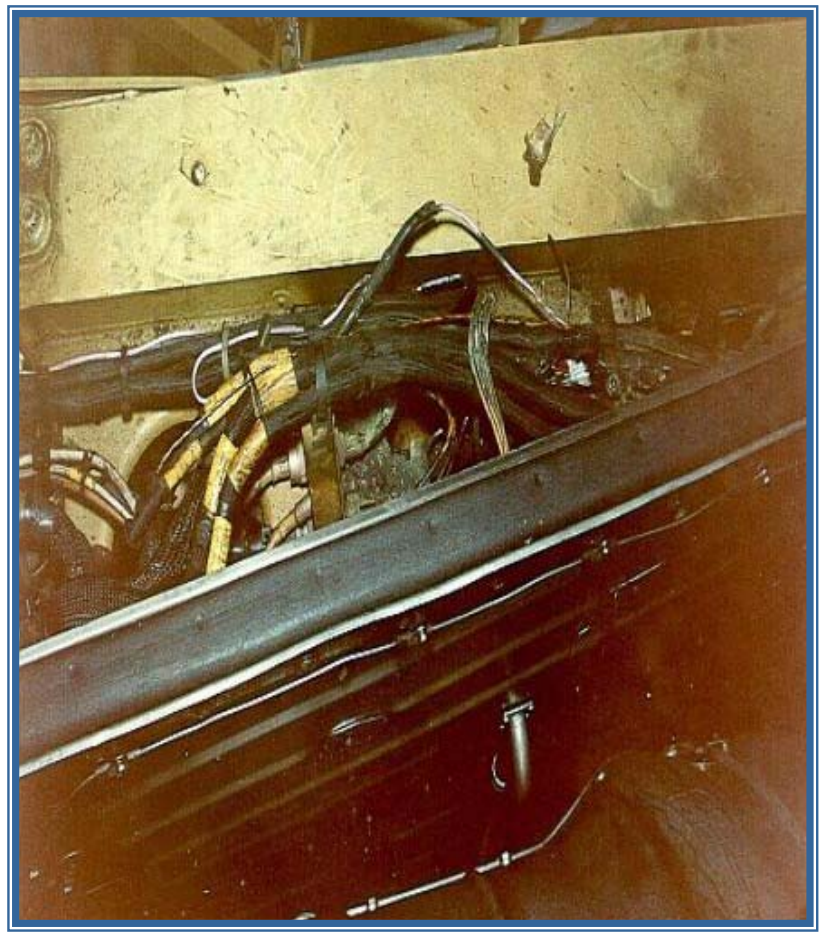
SAE-8B1 AFCB Specification

- Society of Automotive Engineers Aeronautical Division
  - Protective Device committee (SAE-AE8B1)
  - Updating SAE 58091 (Formerly MIL-C-5809) Circuit Breaker Specification for Thermal and Arc fault protection
  - Preliminary Spec Available September 2001
  - Finalized January 2002



Pro's of Installing AFCB's into Circuits

- Prevents catastrophic damage to wiring system
- Reduce arc energy for starting fires
- Identifies circuits on which arc faults are occurring
- Actively monitors circuits



Con's of Installing AFCB's into Circuits

- Determining Overload vs. Arc Fault vs. Nuisance Trip
- Assurance of AFCB Functionality
- Additional wire maintenance due to potential increases in trip rates from interconnect system degradation
- Post trip troubleshooting, determining location of arc fault

Implementing Considerations/Approaches

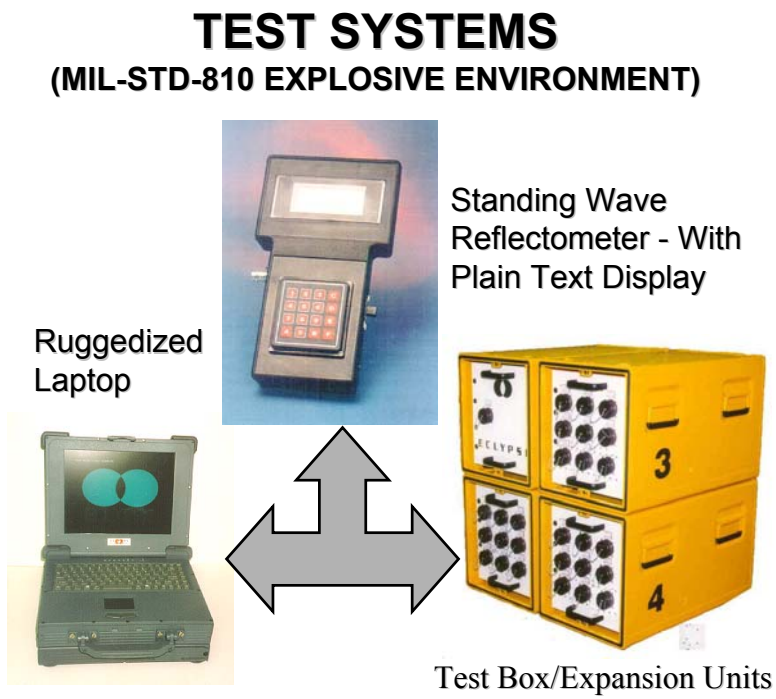
- Fire and Smoke Incident Data
- Maintenance Data
- Reliability Data
- Risk Analysis
- Wiring Zones
  - SWAMP
  - Environmental Conditions
  - High Maintenance Areas
    - Avionics bay
    - Passenger Cabins
    - Cargo compartments

Implementing Considerations/Approaches

- Connected Equipment
  - Non-Flight Critical Equipment
    - Passenger/cargo
  - Flight Critical With Redundancy
  - Emergency Flight Loads
  - Risk Analysis
    - Functional/Physical
    - Intra-system hazards

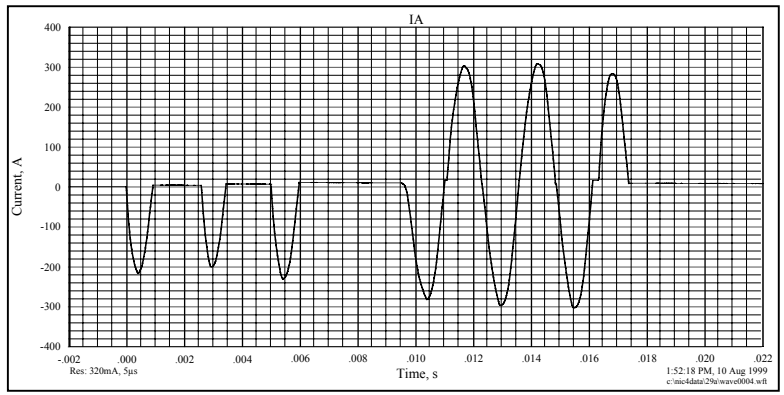
Trouble Shooting Arcs

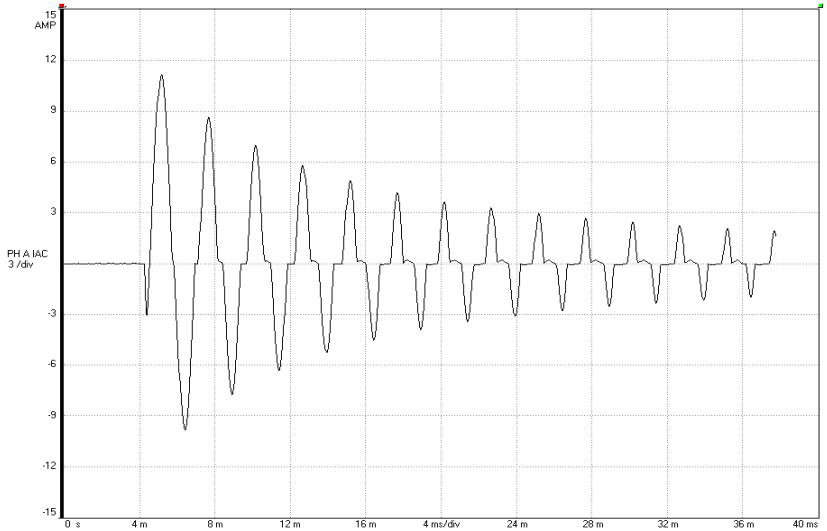
- Off Board Aircraft Wiring Tester
  - VOM
  - TDR/FDR/SWR
- On-board Wiring Diagnostics
  - Smart Wire



Preventing Nuisance Trips

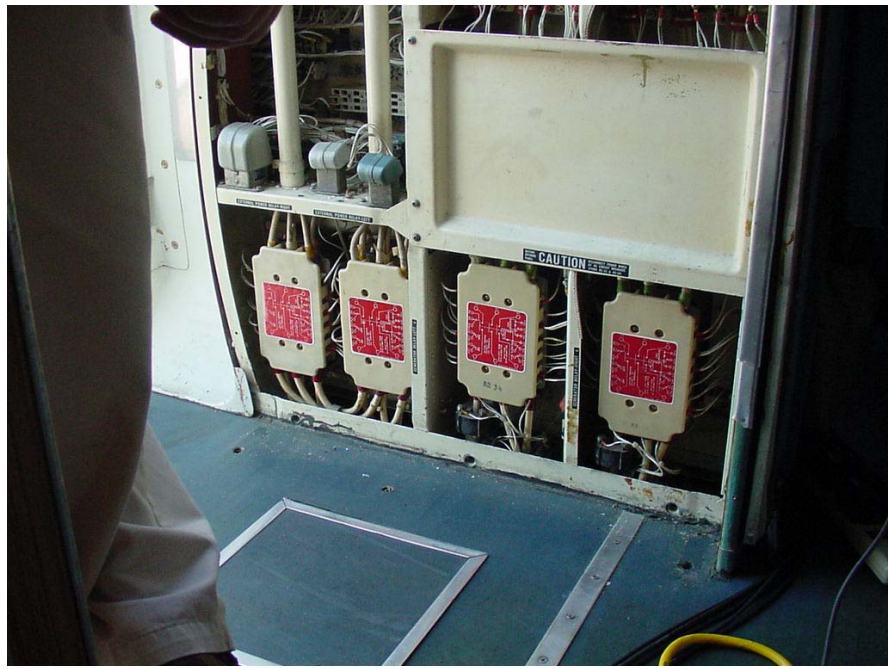
- Determining arc fault detection circuitry health
  - Off Board Tester
  - Internal AFCB Tester
  - Equipment Operation
- Qualification testing
- Load compatibility tests





Future Arc Fault Protection

- Miniaturized single-phase AFCB
- 28 Volt DC AFCB
- Three-Phase AFCB
- Contactors
- Generator Control Units



Advanced Diagnostic and Protection Features

- Diagnostics
  - AFCB Operational Test
    - Internal Built in Test (BIT) vs. External tester
  - Arc Fault Locator
    - Internal versus external
- Circuit breaker communications
- Wire Protection
  - Coordination
    - Arc fault and thermal trip coordination
  - Multiple Protection Devices
    - AFCB, motor contactors, Bus tie contactors, generator control units

Conclusion

- The AFCB program is the first step in implementing arc fault protection.
- System level planning essential to a successful transition to AFCBs and maximizing AFCB benefits.
- Efficient post-trip troubleshooting is essential for maintenance and operation of AFCB equipped aircraft.

Implementing AFCB in various circuit protection devices is in its infancy.