MOVING SHM INTO ROUTINE USE – PROGRESS IN CVM APPLICATIONS

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1. Overview of physics of crack detection using CVM.
3. Applications and status.
4. New regulatory documents.
5. Conclusions.

An In-Situ Crack Detection Solution

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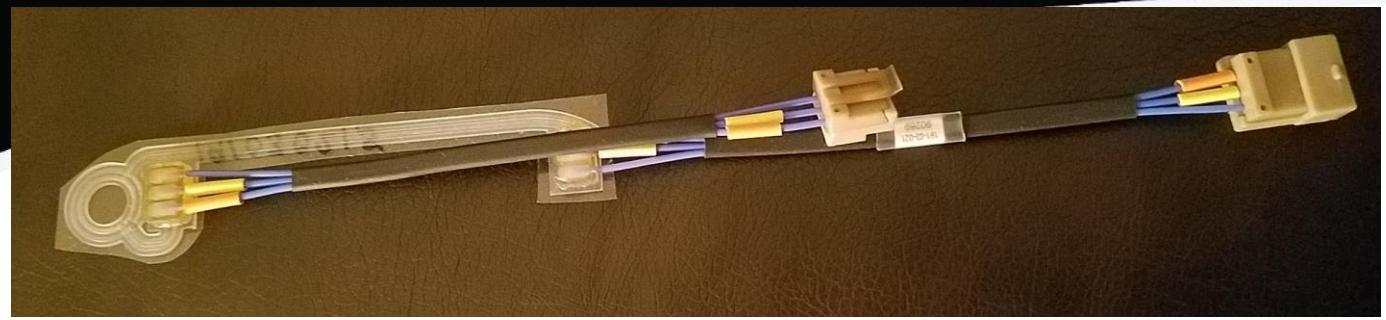
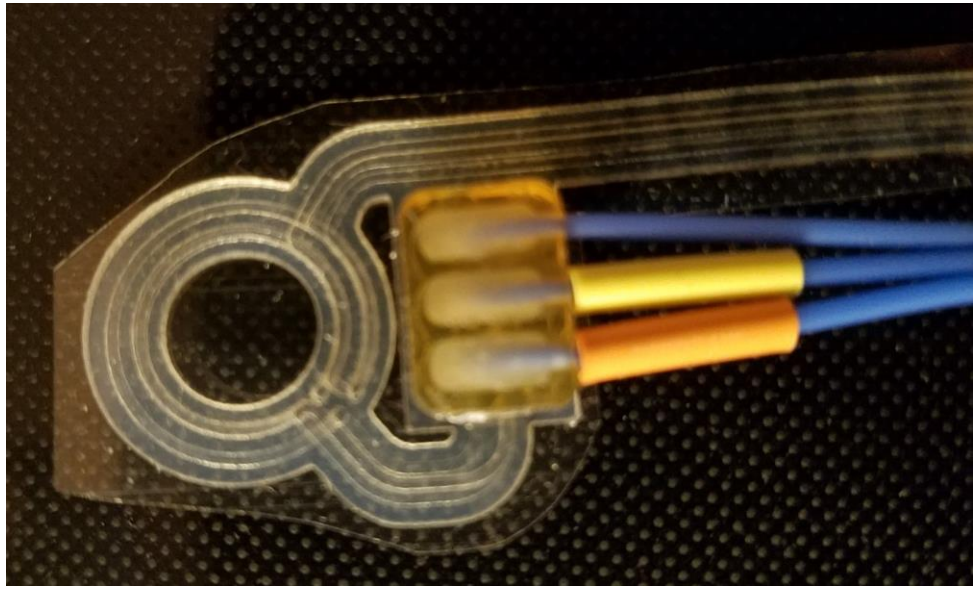
- A quarter century of R&D.
- Developed for use in aerospace environments.
- Fully integrated for in-situ aircraft crack detection.
- Reduces inspection time for structural inspections.
- Increases aircraft utilization.
- Reduces false positive indications.
- Reduces access time and damage during access
- Reduces aircraft down time.
- Does not need to be performed in a hanger environment.
- Fail safe and built in self test technology when we measure for continuity.

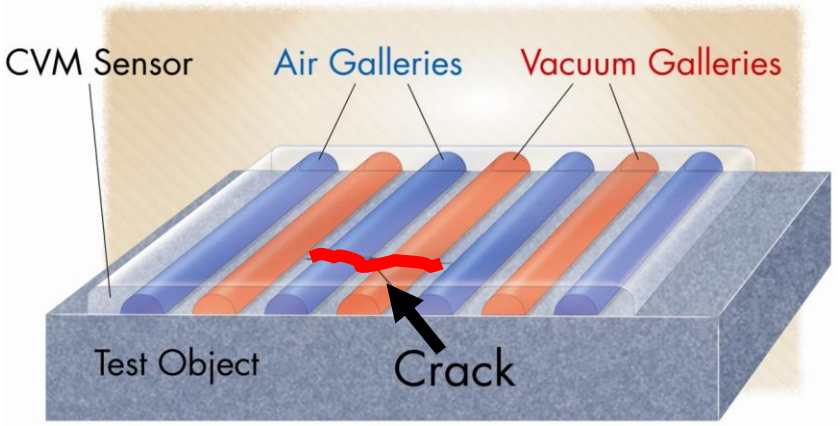
TECHNOLOGY OVERVIEW

Technology Overview

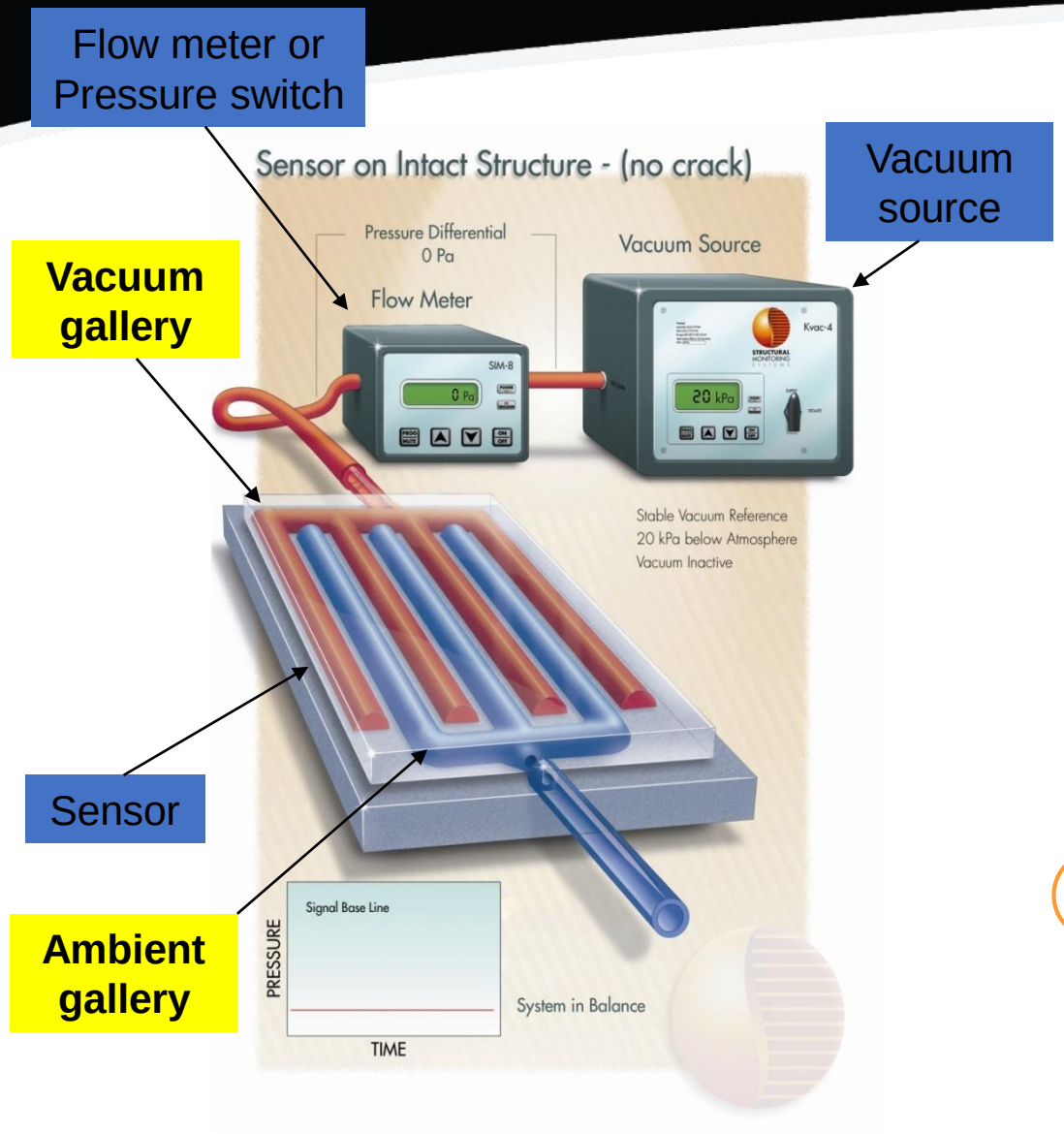




- A sensor has alternating Vacuum (red) galleries and Ambient (blue) pressure galleries.
- Galleries are adhered to the part surface.
- The structure surface becomes an integral part of the sensor system.



TECHNOLOGY – HOW IT WORKS



- A Flow Meter measures the differential across the sensor vacuum gallery and the vacuum source and compares them for any change.
- A steady state vacuum is maintained with no pressure differential being read across the Flow Meter.
- Should a crack occur, a leakage path (breach) between the vacuum and ambient galleries will result.
- As the crack propagates, the bridge across the vacuum & ambient galleries increases causing further loss of vacuum.
- The Flow Meter will display this as an increase in pressure differential as both galleries mix.

TECHNOLOGY – SENSOR INSTALLATION

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- Test fit sensor.
- Clean surrounding area.
- Sand surface smooth.
- Clean surrounding area again with DI H_2O.
- Apply sensor and consolidate to surface.
- Connect tubing to Sensor Lead Socket.
- Test with PM200.
- Fail safe and self test technology when measure continuity

Additional CVM Information

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- Detects surface cracks.
- Sensors are translucent so cracks can be visually detected.
- Currently used on metallic parts with or with out primer. Smaller crack size detected when primer is applied on the parts.
- Sensors have flown on airplanes for 15+ years and still functional.
- Sensors remain onboard during flights.
- Instrument does not remain onboard.
- Customized installation and NDT procedure required for each application.
- Procedures have Frequently Asked Questions (FAQ) and Fault Isolation process.
- Sensors are made from Teflon and are passive, with no EMI or EMC concerns.
- If required, the sensors can be removed to perform other NDT inspections.

Detailed CVM Procedure

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- **Very similar to traditional NDT Procedures**
- Detailed part access as required
- Sensor details and required instrument details
- Necessary materials list
  - Sandpaper grit and type/ DI water/primer/paint/overcoat/rags/scrapers types/solvents/gloves/masks/…
- Inspection locations
  - Distance and tolerance fastener heads/tails…
  - Installation Dwg, showing routing details
  - Lead tie details
- Sensor installation
  - Remove scrape sealant/Fuel Vapor Barrier, sand surface/inspect for paint/primer condition
  - Bulk cleaning steps
  - Detailed Cleaning steps
  - Paint and/or prime requirements
- System tests / calibration
- Inspection process/details
- Fault Isolation Section
  - Flow chart and FAQ

Detailed CVM Procedure (Continued)

STRUCTURAL MONITORING SYSTEMS

a.→Connect the Verification Block to the Instrument Lead.¶
b.→Turn on the PM200. Follow on screen prompts.¶
c.→Select operator.¶

PM200 Operator Selection Screen¶

¶

d.→If the Instrument Lead is not connected, the PM200 will prompt for its connection.¶

PM200 Connect Instrument Lead Screen¶

¶

e.→If the Sensor Lead Socket is not connected, the PM200 will prompt for its connection.¶

¶

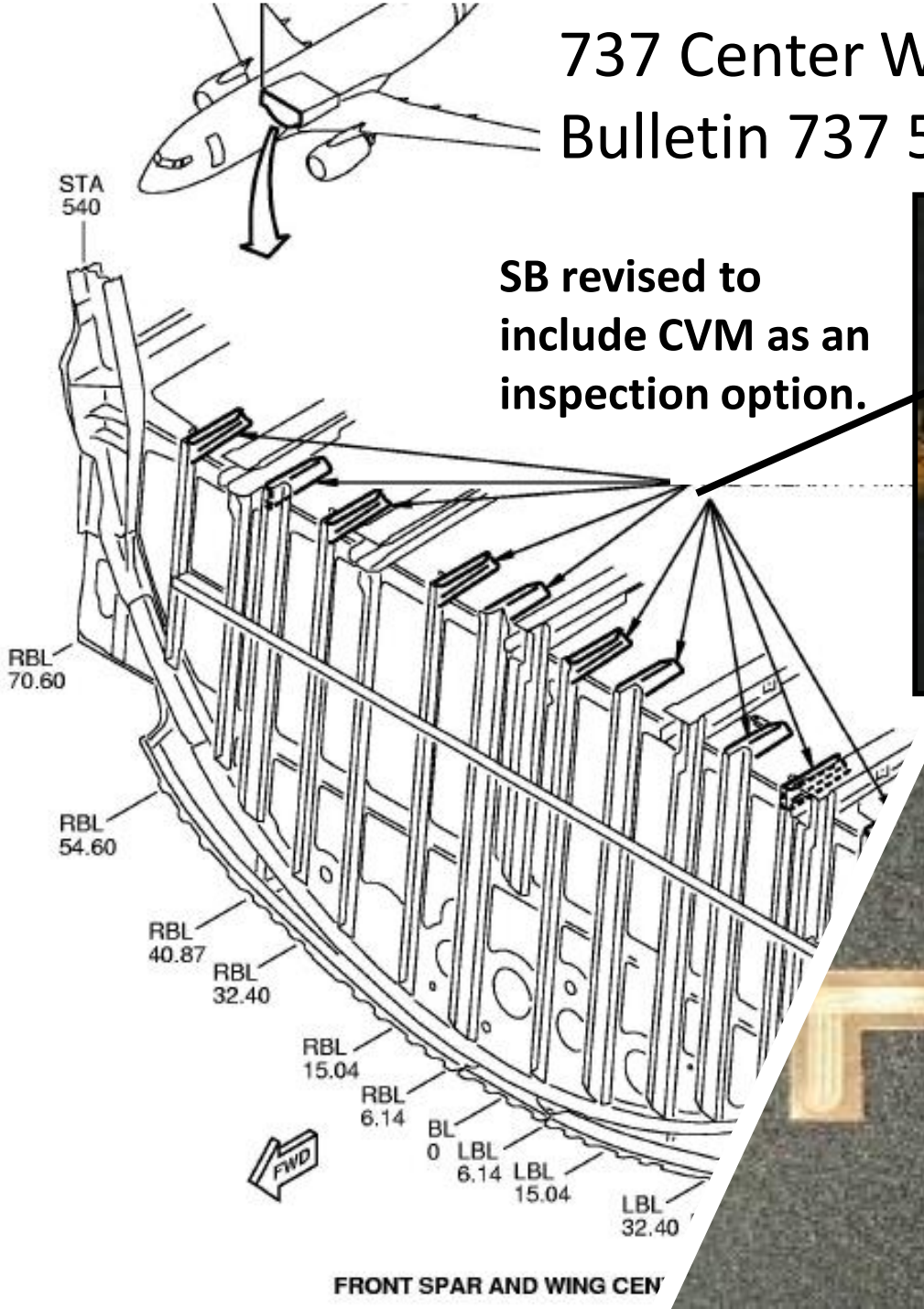
f.→Press Start to Begin Test.¶

PM200 Press Start to Begin Test¶

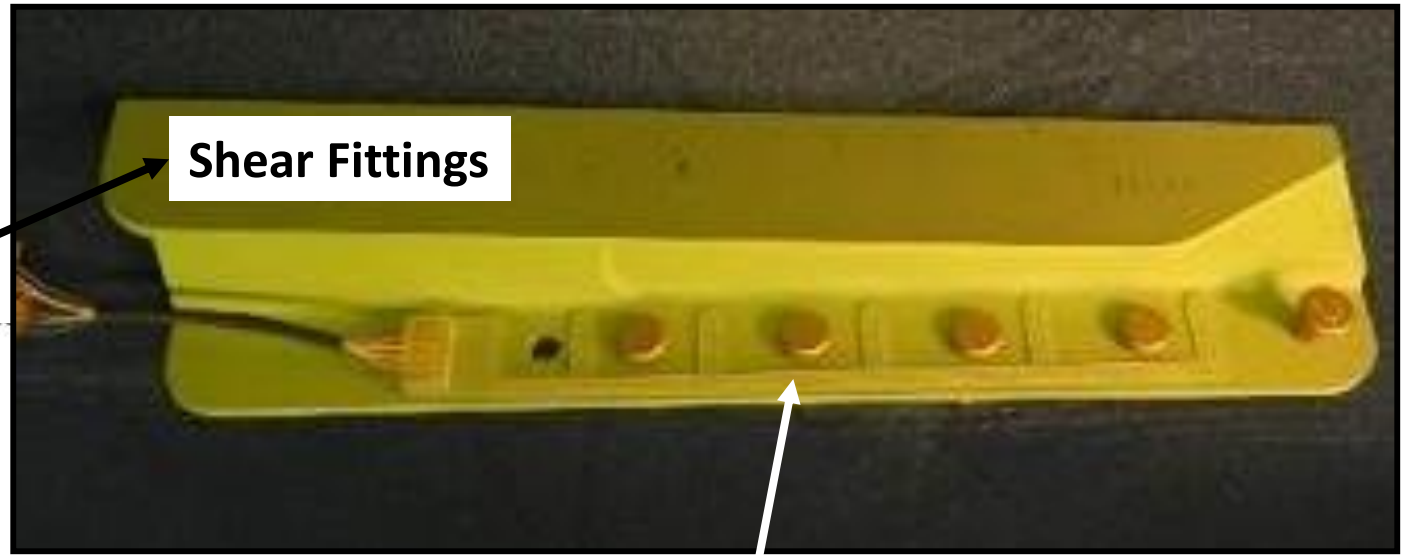
g.→After completion of a successful test the PM200 should report ALL TESTS PASSED. If any other screens other than the above sequence occur, refer to the PM200 Operator's Manual.¶

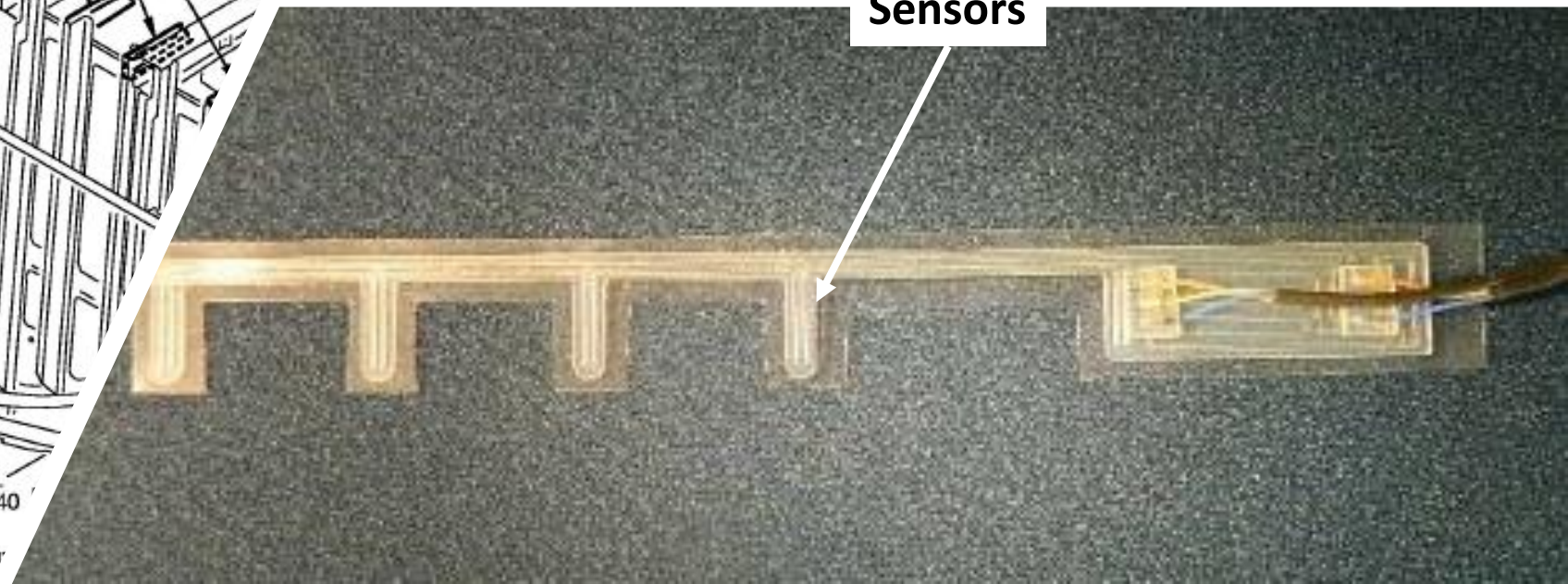
CVM™ APPLICATIONS

737 Center Wing Box Front Spar Shear Fitting Service Bulletin 737 57-1309



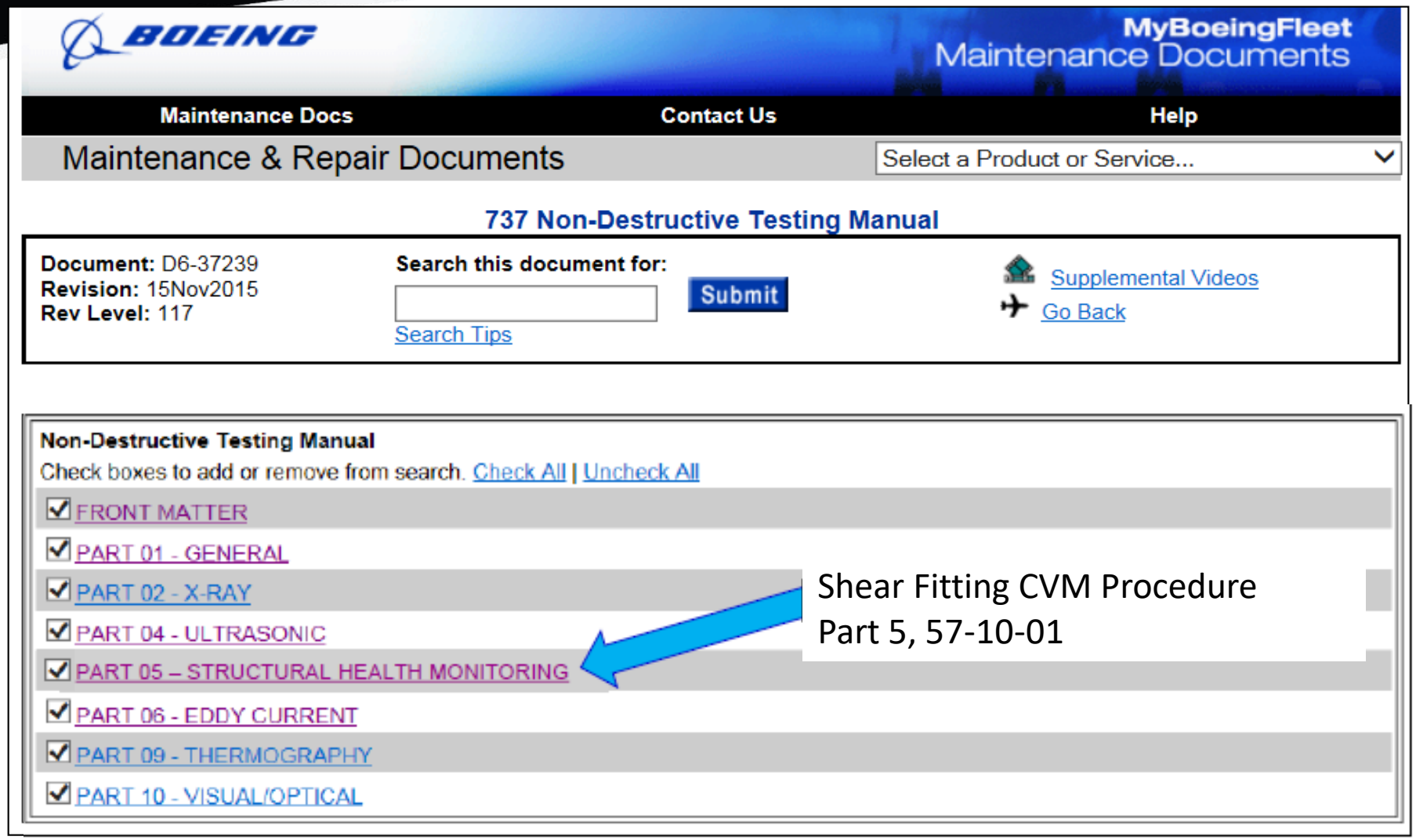
SB revised to include CVM as an inspection option.



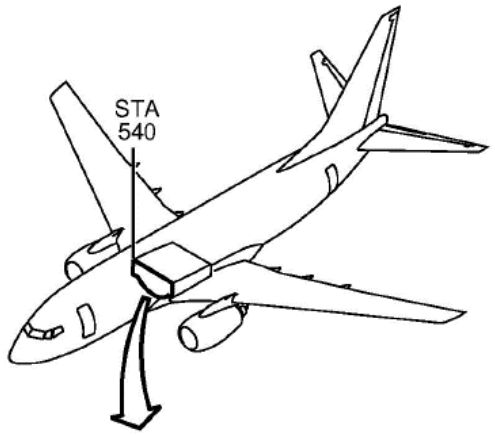


737 NDT Manual - New SHM Chapter Published (Nov 2015)

STRUCTURAL MONITORING SYSTEMS plc



Boeing Service Bulletin – Revised to Allow for Routine Use of SHM Solution (June 2016)



DO A DETAILED INSPECTION OR COMPARATIVE VACUUM MONITORING (CVM) INSPECTION OF THE CENTER WING BOX FRONT SPAR SHEAR FITTINGS FOR ANY CRACKS. IF ANY CRACK IS FOUND, REMOVE THE DAMAGED SHEAR FITTING, MAKE SURE THERE IS NO CRACKING IN THE UPPER PANEL AND INSTALL A NEW SHEAR FITTING AS GIVEN IN THIS SERVICE BULLETIN.

AT EACH SHEAR FITTING, IF NO CRACKING IS FOUND IT IS OPTIONAL TO ACCOMPLISH THE PREVENTIVE MODIFICATION BY REPLACING THE SHEAR FITTINGS.

BOEING SERVICE BULLETIN 737-57-1309

BOEING

Commercial Airplanes

737

Service Bulletin

Number: 737-57-1309
Original Issue: January 28, 2011
Revision 1: June 27, 2016
ATA System: 5714

Revision Transmittal Sheet

SUBJECT: WINGS - Center Wing Box - Front Spar Shear Fitting - Inspection, Repair and Preventive Modification

This revision includes all pages of the service bulletin.

COMPLIANCE INFORMATION RELATED TO THIS REVISION

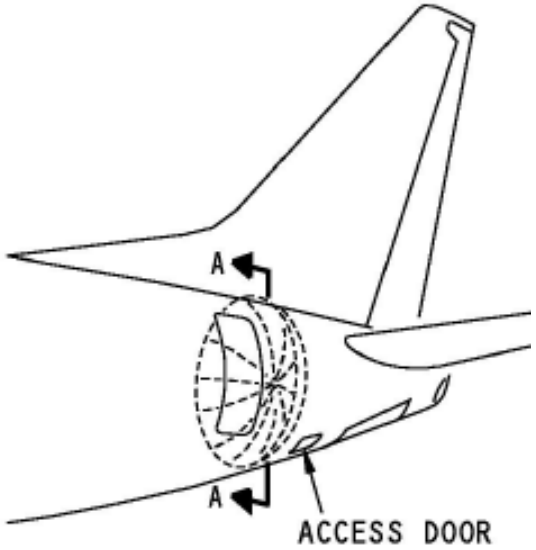
Effects of this Revision on airplanes on which Original Issue was previously done:

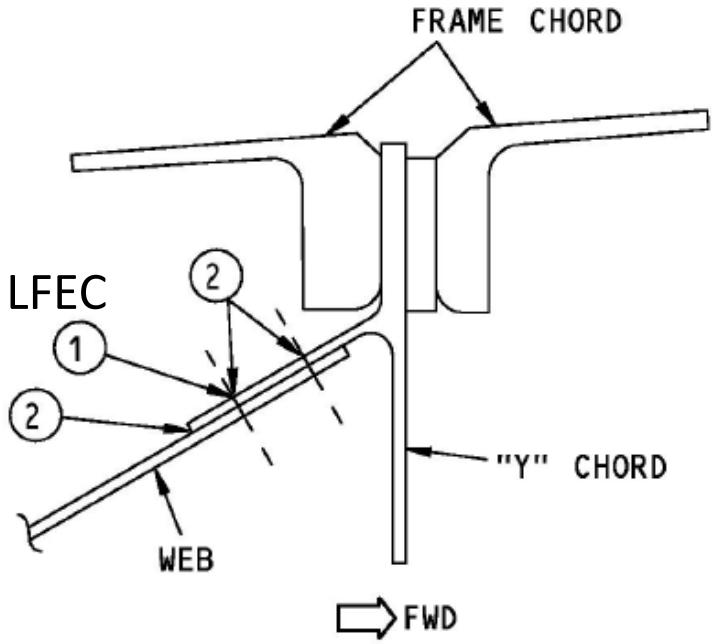
None.

REASON FOR REVISION

This revision is sent to add a Comparative Vacuum Monitoring (CVM) inspection as an alternative inspection method for the front spar shear fitting. In addition, illustrations in figures are changed to show correct views, footnotes are added in fastener tables for clarification and footnotes in figures are changed to clarify sealing instructions.

Boeing Service Bulletin – 737 53A1248 Aft Pressure Bulkhead Inspection





- 1,200 FC repeat threshold for LFEC and detailed inspections Aft side S-5L to S-7L and S-5R to S-9R.
- CVM sensors installed on the Fwd side of the APB.
- Approximately 21-23 sensors chains per airplane
- Access time and Inspection ~ 1hr 15 min
- Airline reported 12 Hrs typical
- Reduced airplane downtime, reduced false calls, reduced inspection times

737 Aft Pressure Bulkhead

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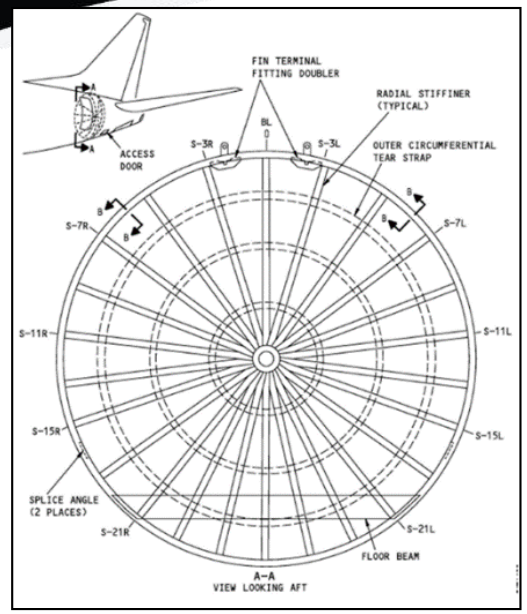

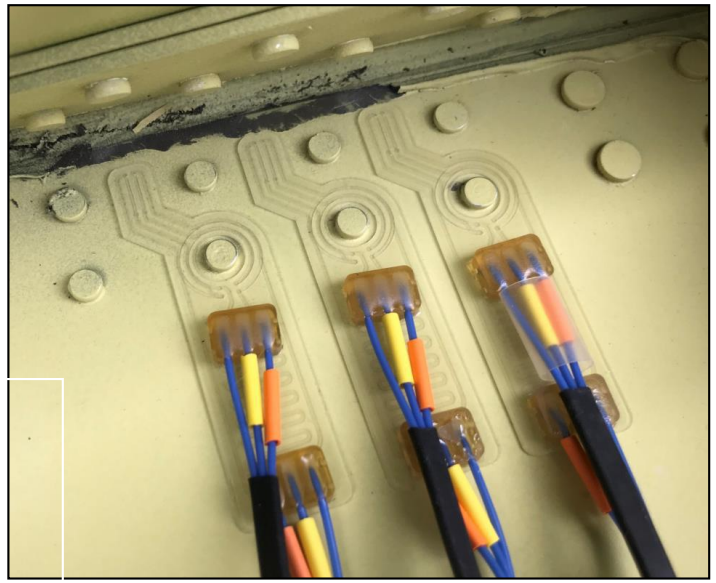

Circumferential cracks at fasteners connecting the web assembly to the bulkhead “Y” chord.

20 aircraft installations in 2019

WiFi Antenna Installation Structure (multiple aircraft types, multiple airlines)

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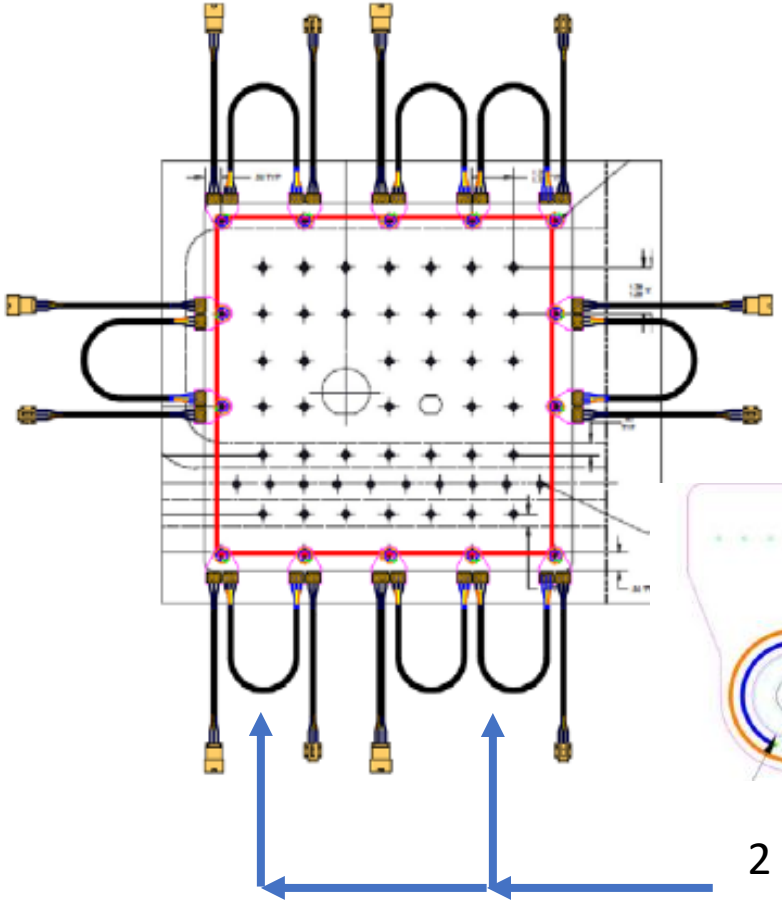
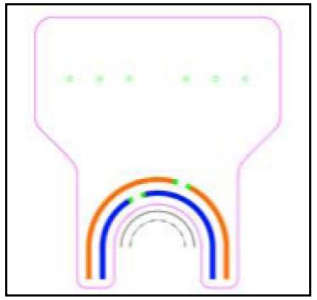


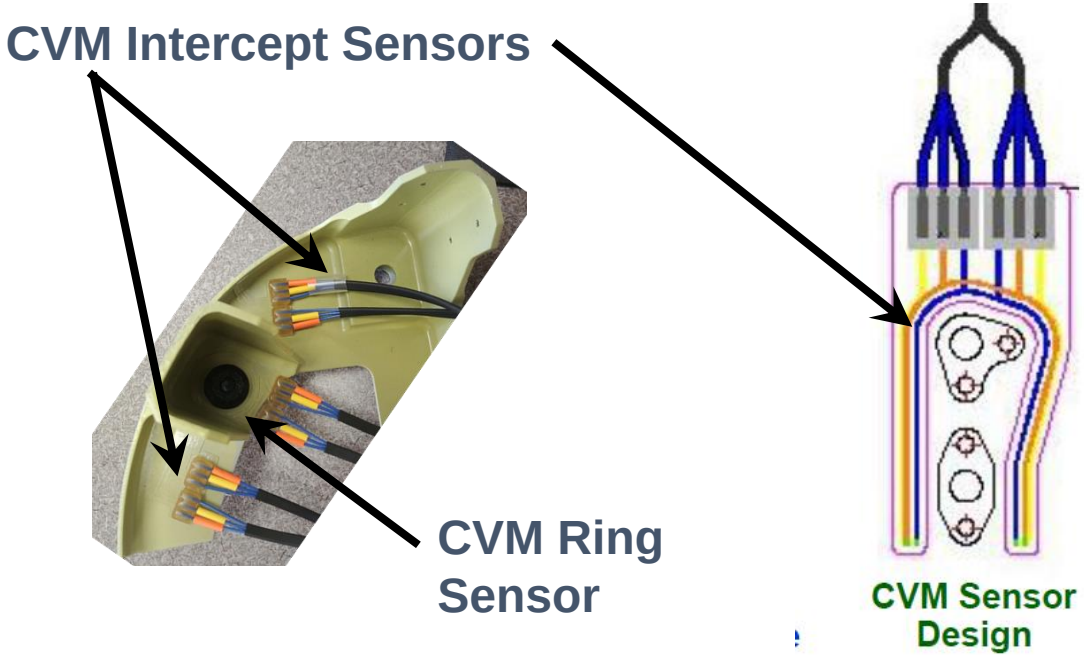


CVM Sensor Horseshoe Design and Ring Sensors Many other Designs

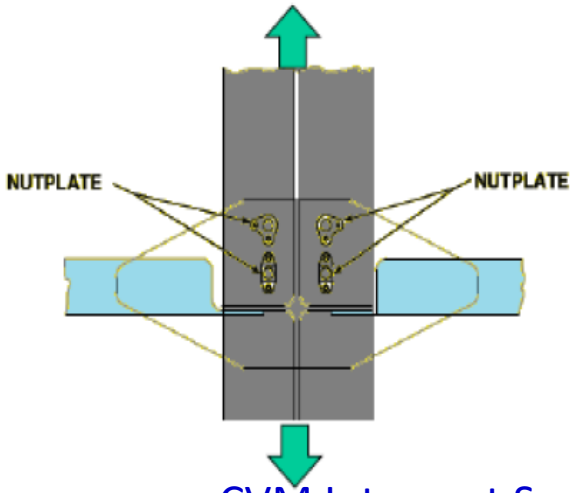
CVM sensors used to rapidly complete frequent, repeat HFEC/LFEC inspections required on internal structure hidden behind interior panels.
Anticipate Installations in 1th Q 2020

2 Ring and 3 Sensor ganged together

CVM Applications on Rotorcraft



- Cracks originate at bolt hole (bore) with propagation in multiple directions
- Inspection requirement – visual (1” – 2” L crack)



CVM Ring Sensor

- Will detect cracks after they extend out from under the fastener - sensitivity will exceed visual detection capabilities and match eddy current inspections
- May be the only sensor needed (on each side) if cracks originate here

CVM Intercept Sensors

- Monitors for cracks that may originate from upper row of fasteners
- Fits between the fasteners and mounts around the radius corner

MANUFACTURING AND ENGINEERING

AEM CERTIFICATION AND STANDARDS

STRUCTURAL MONITORING SYSTEMS plc

- Transport Canada Approved Manufacturer and Maintenance Organisation, pending Design Approval Organisation (DAO)

  Certification Manager – Trevor Lynch-Staunton

- EASA Part 145 European Maintenance Approval

- ISO9001/AS9100C registered

- Registered, Canadian Controlled Goods Program (CGP)

  - Eligible for ITAR Exemptions

- Illuminated front panel design and manufacturing per SAE AS7788, DO-275 and MIL STD-3009

AEM ANODYNE ELECTRONICS MANUFACTURING CORP.

Regulators New Documents

STRUCTURAL MONITORING SYSTEMS plc

- FAA AC 43-218 Draft Released by **Flight Standards Service Division**
  - Provides guidance to develop an operator's Integrated Aircraft Health Management (IAHM) program.
  - Encompasses aircraft systems, data transmission, and data analysis/implementation.
    - Describes Design Approval Holder (DAH) responsibilities.
    - Outlines trigger requirement for maintenance action.
    - Provides training, data transmission performance, and data security requirements.
    - Not to be used as a substitute for the performance of a Required Inspection Item (RII).
    - Requires operator procedures and notification to regulatory oversight office of intent.

- FAA **Transport Standards Branch** Currently Working on Issue Paper (IP) to establish the minimum requirements of a specific CVM application. This IP will be used develop the general requirements of a generic IP for other SHM applications to satisfy regulator inspection compliance.
    - Required testing for structural, environmental, materials, coatings, durability, and systems tests.
    - Probability of Detection (POD) methods and requirement's.
    - Impact of SHM on-board equipment with the ability to perform other NDT inspections.
    - Proven reliability and high confidence of performance.

Conclusions

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- Cost savings technology
- Many different applications in aviation and other applications
- Transitioning from research to routine applications
- FAA provided SHM requirement documents

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