



**Aging Aircraft 2009**

**12<sup>th</sup> Annual Joint FAA/DOD/NASA Conference**

**Kansas City, MO**

**May 4-7, 2009**

**Piper Comanche Stabilator Torque Tube Horn Cracking Study  
A Type Club Investigation**

**International Comanche Society  
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**Hans Neubert, Technical Committee, FAA Liaison**

**DERT-605393-NM**

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## Background Information

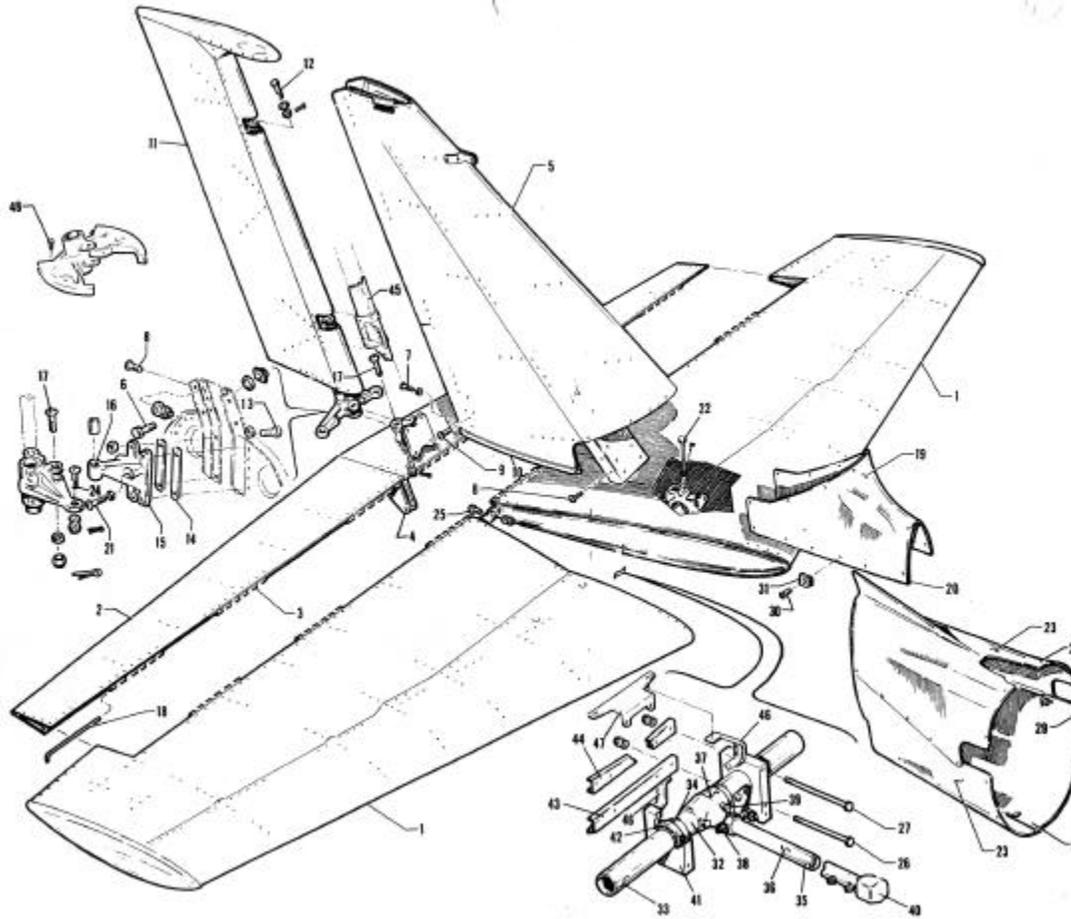
- International Comanche Society is the recognized Type Club for the Piper PA 24 / 30 / 39 aircraft series.
  - *6999 aircraft produced, ~4660 remain in registry WW*
  - *ICS membership ~ 3000 members*
  - *Provides Type, Technical and Social Support*
- Cracking of Stabilator Torque Tube Horn discovered in 2006
  - *No new parts available or in production*
  - *Cracking forms from the inside out*
  - *Serviceable parts taken from salvaged aircraft*
  - *Investigation initiated to determine root cause and who is at risk*



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# Empennage Assembly



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## Typical Cracked Torque Tube Horn



**NOTES: Cracks observed on singles only. Cracks only observed on early model singles (1958 – 1961). Forward cracks observed at ~3800 hours, while forward and aft cracks observed at ~4900 hours. Later models with higher times have not cracked. No cracks found on Twins or 400 Model singles.**

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## Initial Society Response

- Alert the membership of potential problem:
  - Monthly magazine “Comanche Flyer”
  - ICS Web Site
  - Delphi Comanche Owners Group Web Site
  - Fly-In Technical Seminars
  - Maintenance Clinics
- Technical Committee Actions
  - Initiate a “Triage” of the fleet
  - Initiate a technical cause and solution investigation
  - Provide guidance to members on inspection procedures



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## Investigation Hypothesis

- Common part (P/N 20397-00) used on all models.
- Suspected causes
  - *Vibration in Stabilator system ?*
    - Trim drum play, rod end play, loose control cables
    - Counterbalance weight out of tolerance
    - Stress Concentration at bore intersection
    - Propeller slipstream coupling to stabilator
  - *Metallurgical differences in early/late 2014-T6 forgings ?*
- Significant (30%) GJ torsional torque tube stiffness difference between Singles and Twins ?



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## Approach

- Contact Piper for limited production run
  - *Initiated by Comanche Flyer Foundation*
- Reverse engineer torque tube horn (just in case)
- Develop FEA model to evaluate installed condition
- Collect stabilator vibration data
- Perform random vibration analysis
- Perform crack growth analysis



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## Comanche Flyer Foundation Efforts

- CFF underwriting tooling and NRE for Piper limited production run (150 units)
- Forgings completed
- New equipment and tooling required by Piper
- Piper status is unknown – Economic challenges
- Recent passing of CFF President in Champ 7HC accident has current status in limbo.

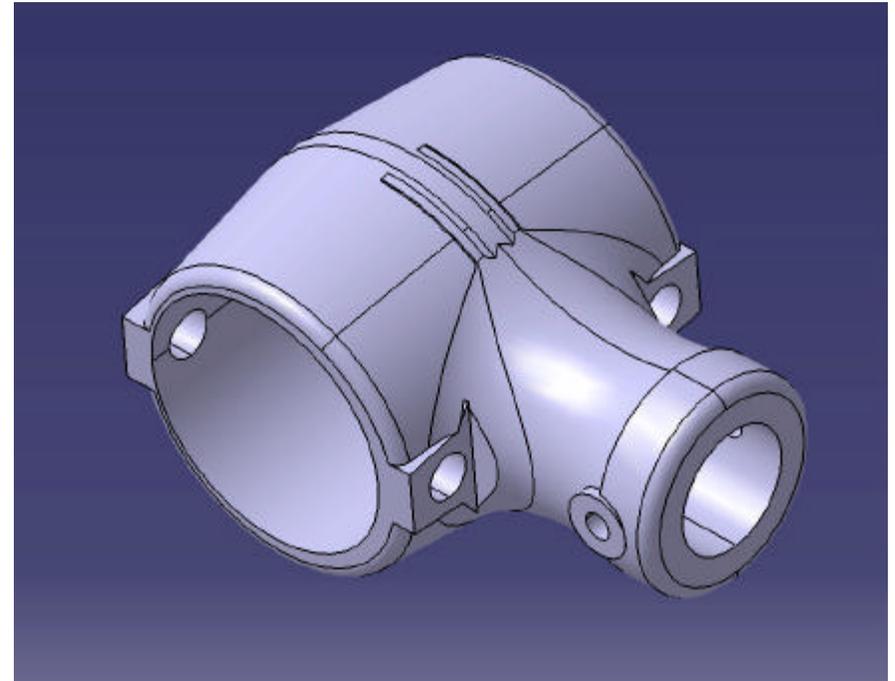
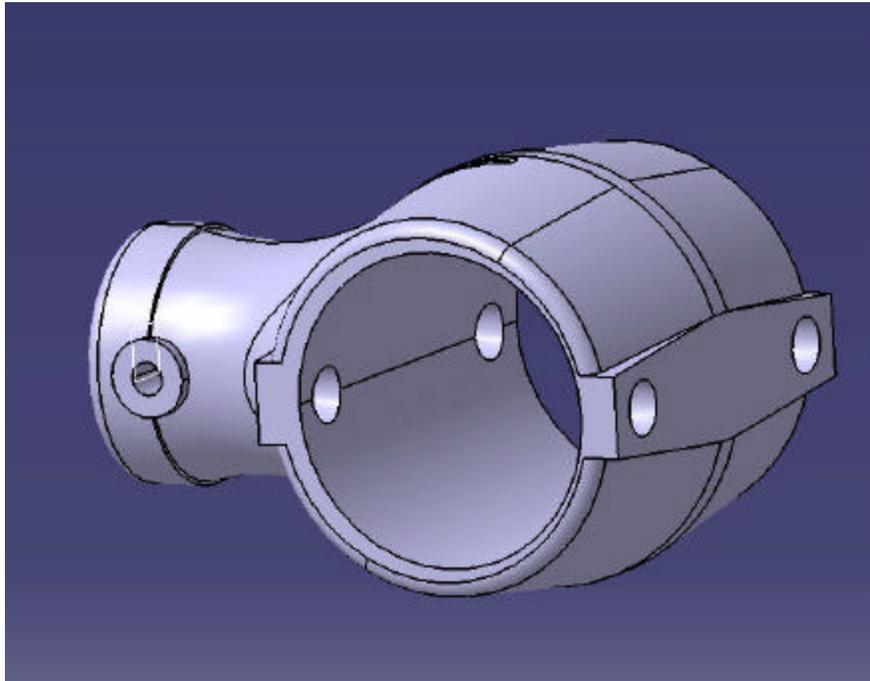




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## 3D Model



**Notes: 3D Model required for CNC machining and FEA Model**

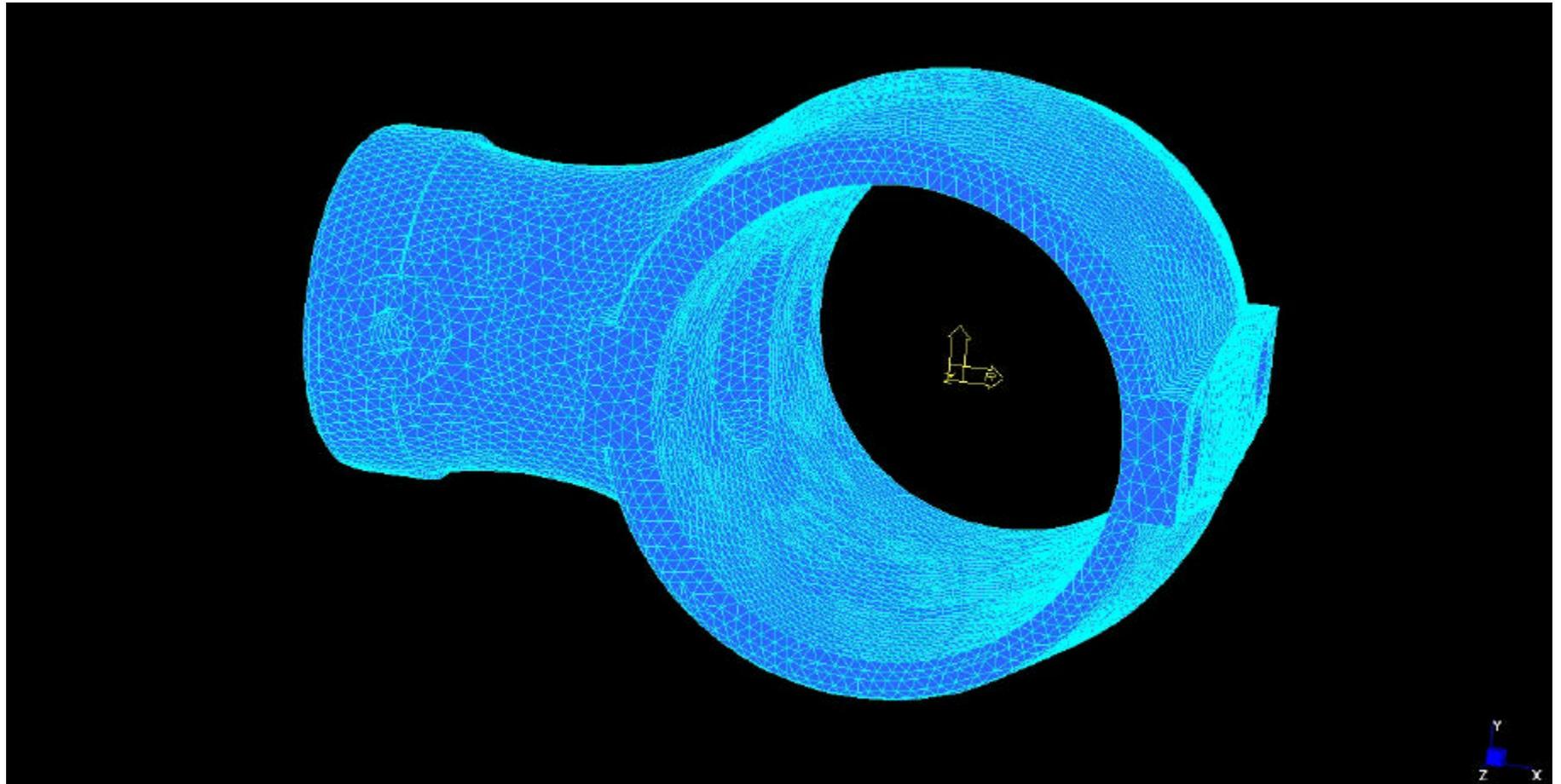
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## Strand 7 FEA Model



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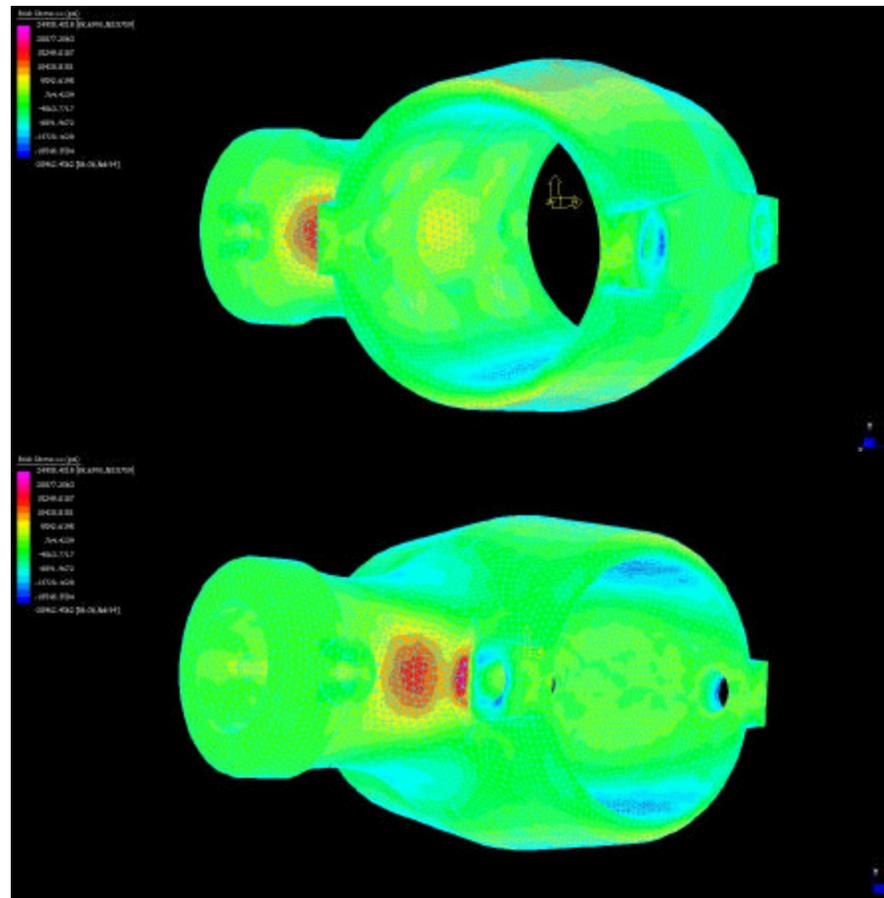


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## Strand 7 FEA Model – Installed Condition

**XX Stresses**  
**24905 psi tension**  
**-20962 psi comp'n**



**Notes: Installed condition is interference fit with counterbalance arm and bolt pre-load to torque tube.**

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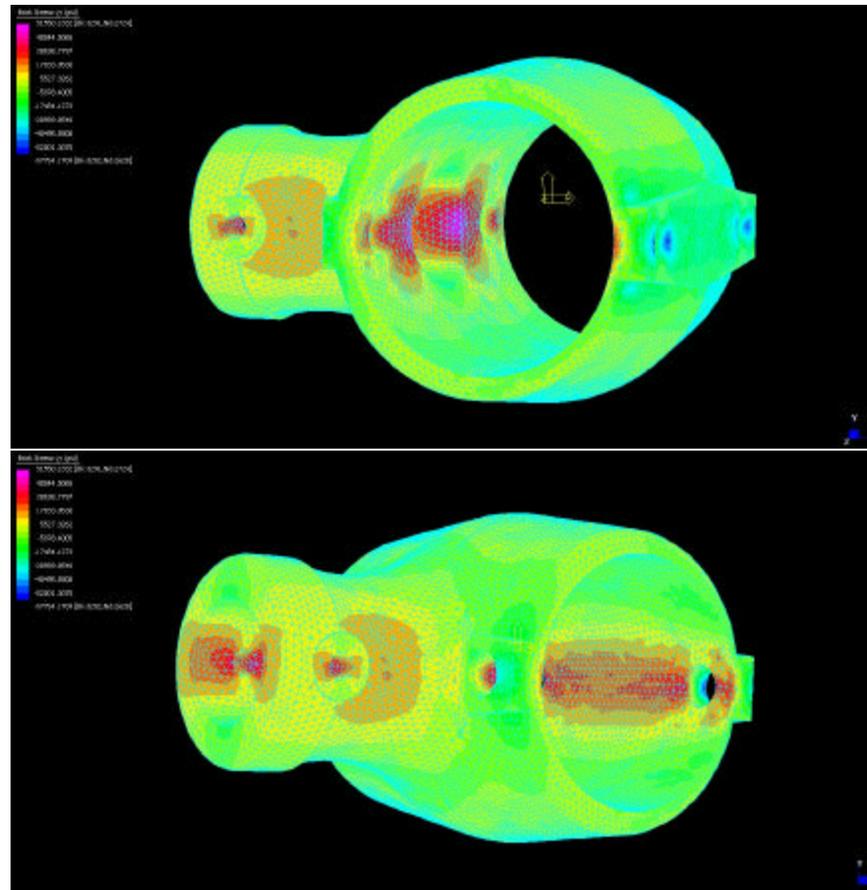


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## Strand 7 FEA Model – Installed Condition

**YY Stresses Max  
51550 psi tension  
-57754 psi comp'n**

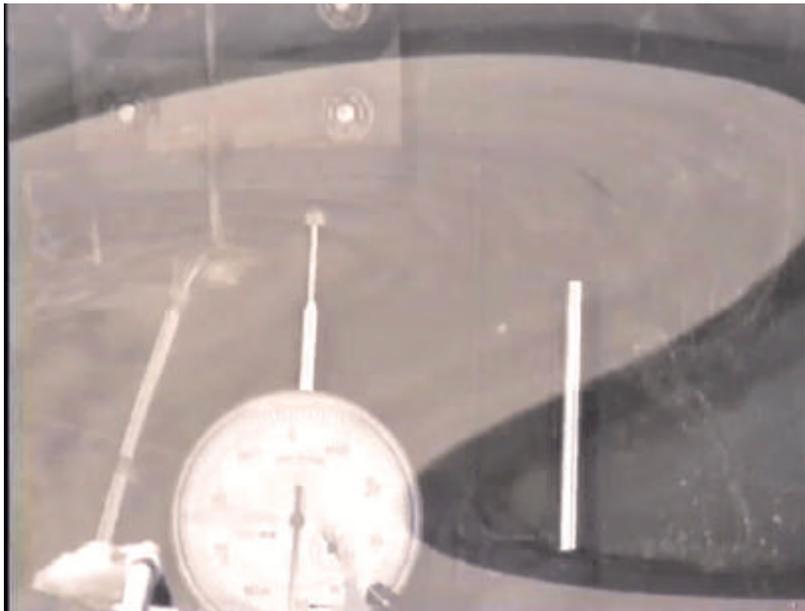


**Notes: Installed condition is interference fit with counterbalance arm and bolt pre-load to torque tube.**

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## Vibration Measurement with Dial Indicator



**Notes:** Test aircraft is a 1962 250 single. Stabilator restrained by elevator up-spring and foam pipe insulation ( $k \sim 25 \text{ lb/in}$ ). Dial indicator oscillations impossible to read directly or from video tape. Excursions  $\sim .125$  inches.

## Vibration Measurement with LVDT's



**Notes:** Brackets fabricated from aluminum sheet to support 5 KHz AC LVDT's measuring stabilator leading edge and counterbalance weight motion. Output to oscilloscope not successful. Data taken from digital displays (~.5 Hz refresh rate).

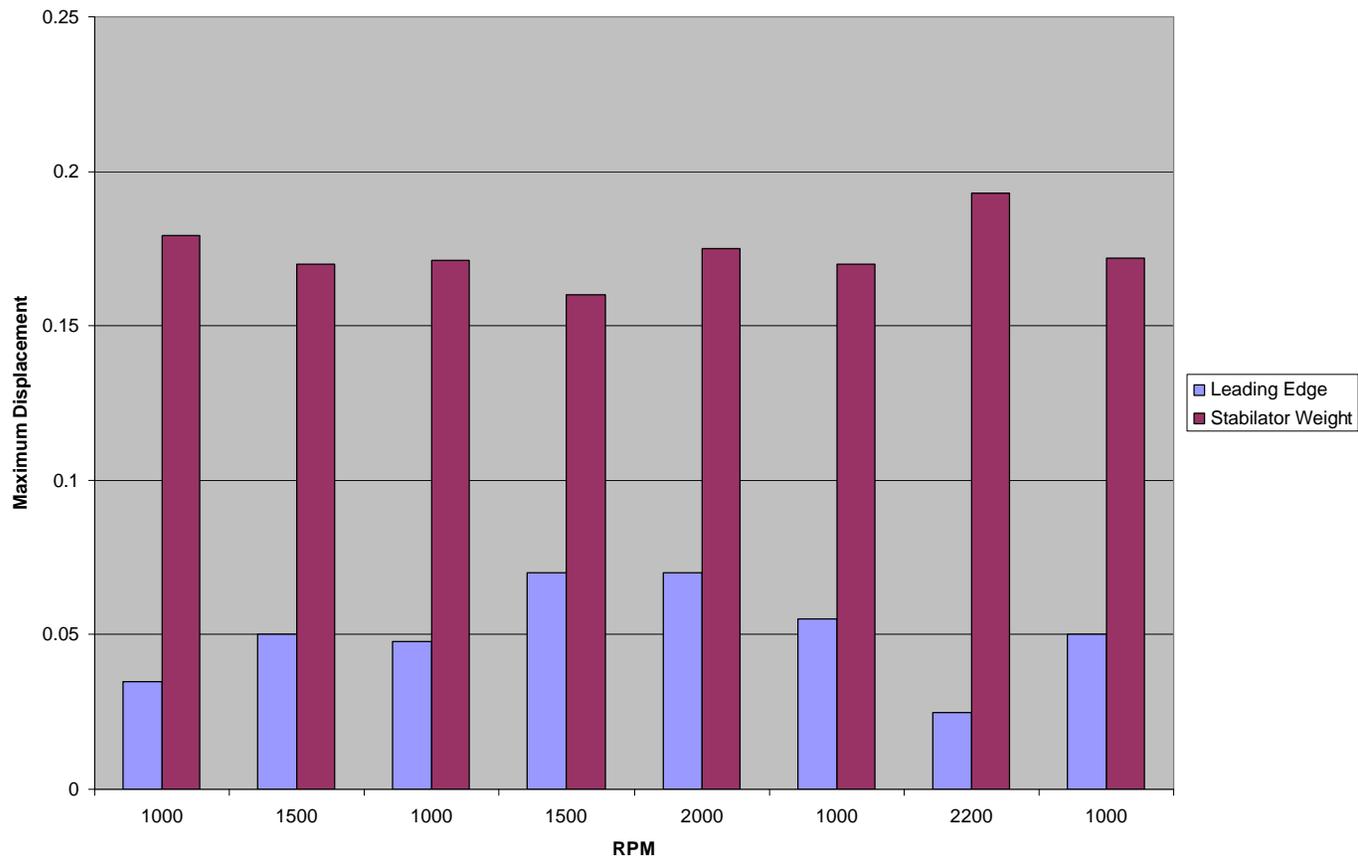


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## LVDT Data

LVDT Data from Digital Readout



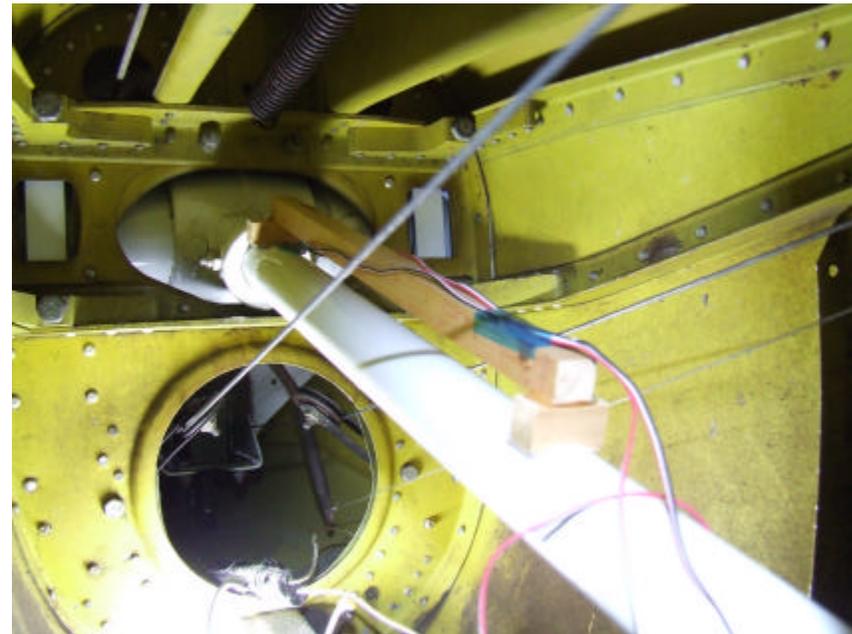
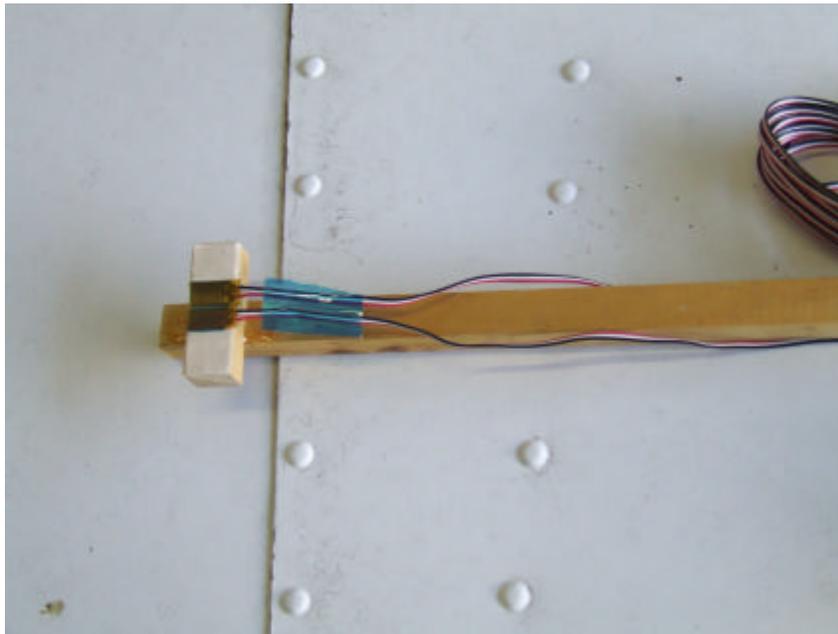
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## Vibration Measurement with Strain Gages



**Notes: Gages installed and calibrated. Gages connected to half-bridge, and ground runs made. Oscilloscope readings unrealistic/unreliable.**



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## Conclusion

- Vibration survey testing has been inconclusive.
- Root cause of horn cracking has not been determined.
- We need help !
  - *FAA Tech Center ?*
  - *Academia ?*
  - *Industry ?*
- Organizational Contact
  - *Dave Fitzgerald, ICS President*
  - [Aaviator@neo.rr.com](mailto:Aaviator@neo.rr.com) (330) 484-4609
- Technical Contact
  - *Hans Neubert, Technical Committee*
  - [Hdneubert@sbcglobal.net](mailto:Hdneubert@sbcglobal.net) (714) 998-1365