

Aging Aircraft 2009

12th Annual Joint FAA/DOD/NASA Conference

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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

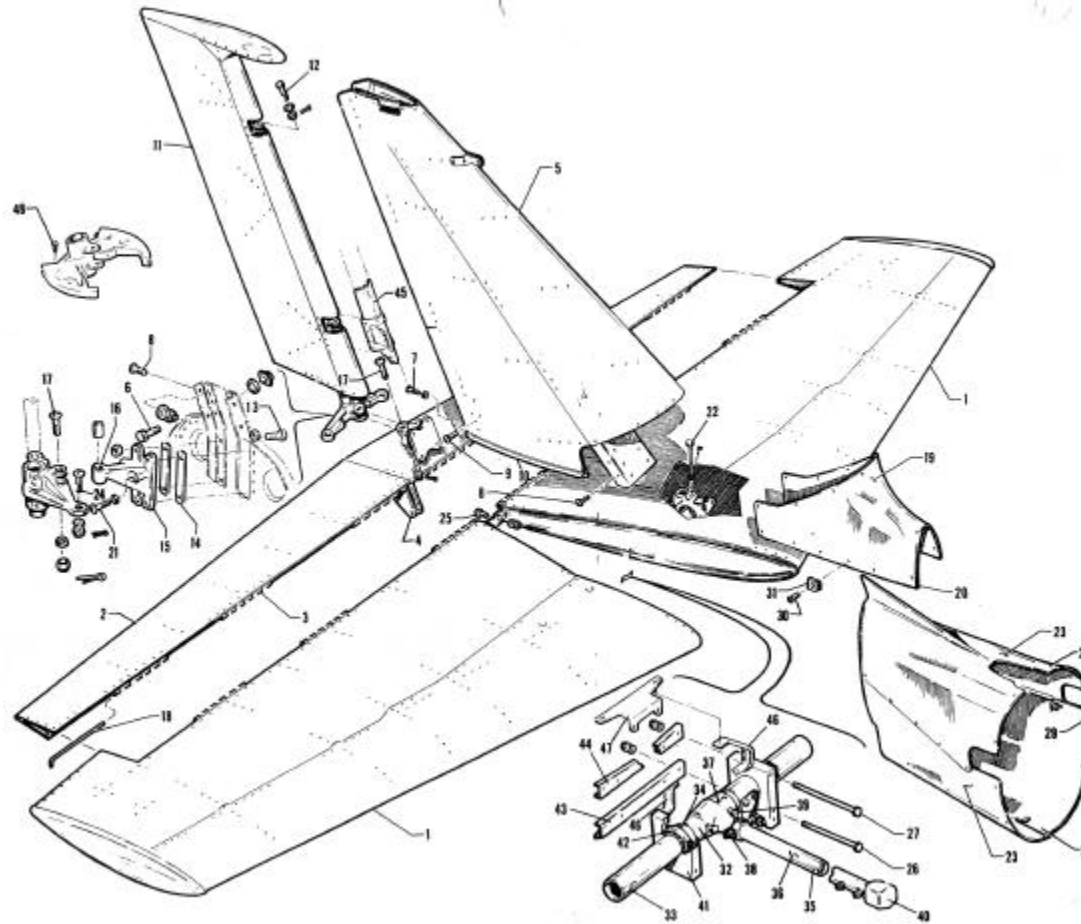
- International Comanche Society is the recognized Type Club for the Piper PA 24 / 30 / 39 aircraft series.
 - *6999 aircraft produced, ~4660 remain in registry WW*
 - *ICS membership ~ 3000 members*
 - *Provides Type, Technical and Social Support*
- Cracking of Stabilator Torque Tube Horn discovered 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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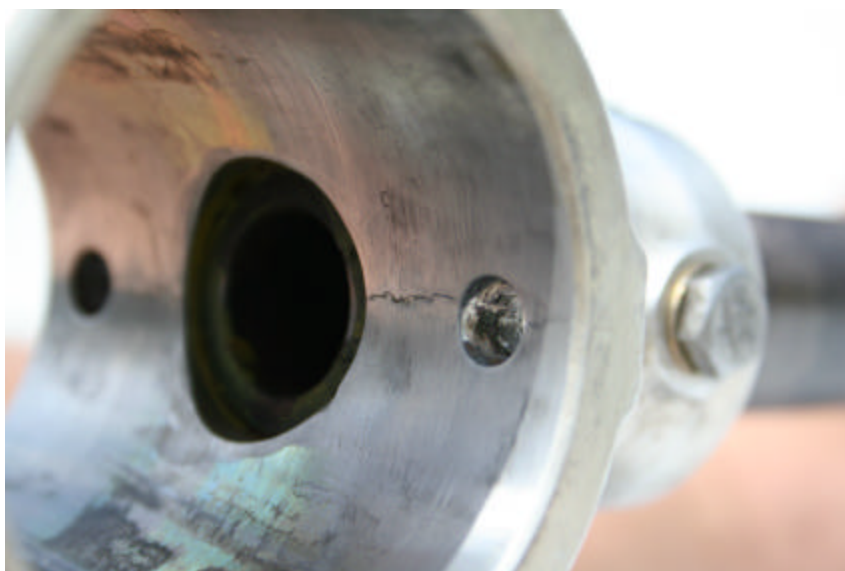
Empennage Assembly



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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



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 ?



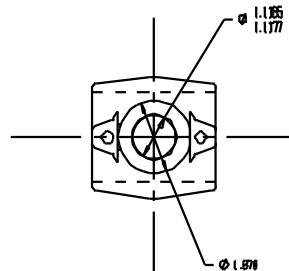
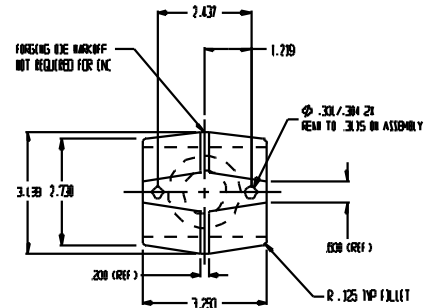
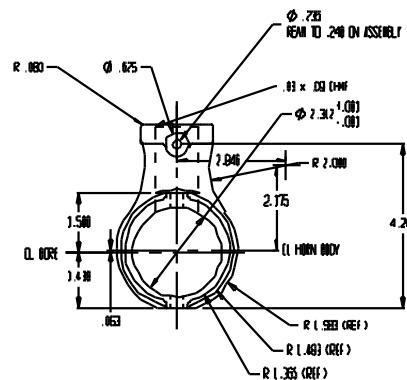
Approach

- 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



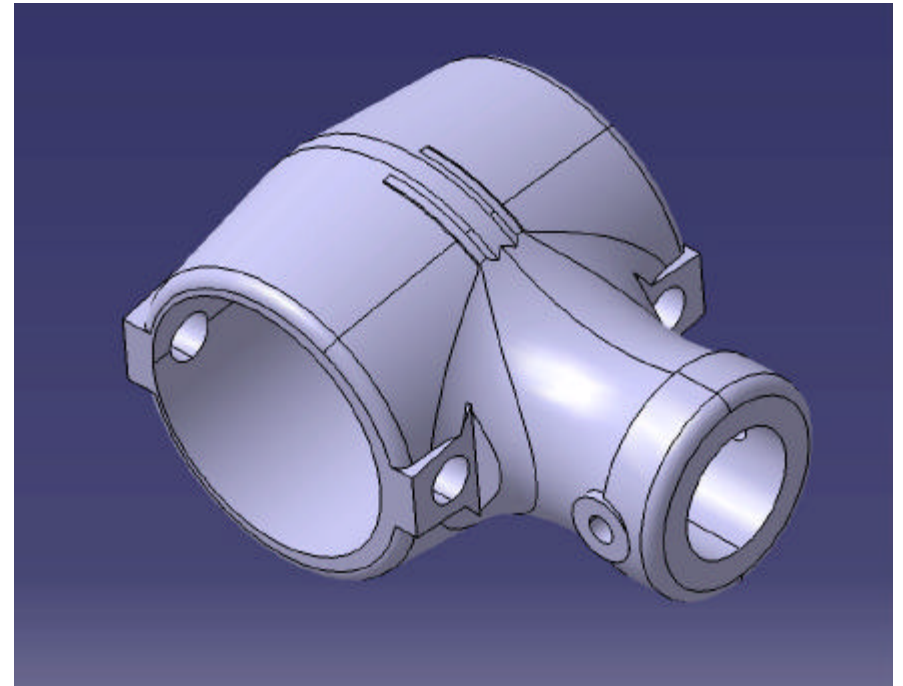
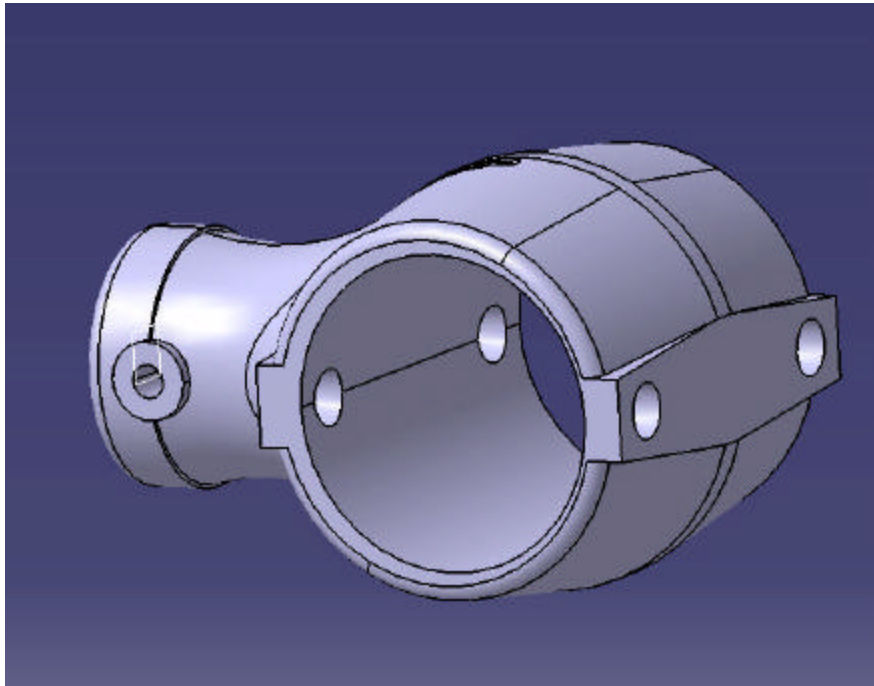
Comanche Flyer Foundation Efforts

- 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.

[illegible]



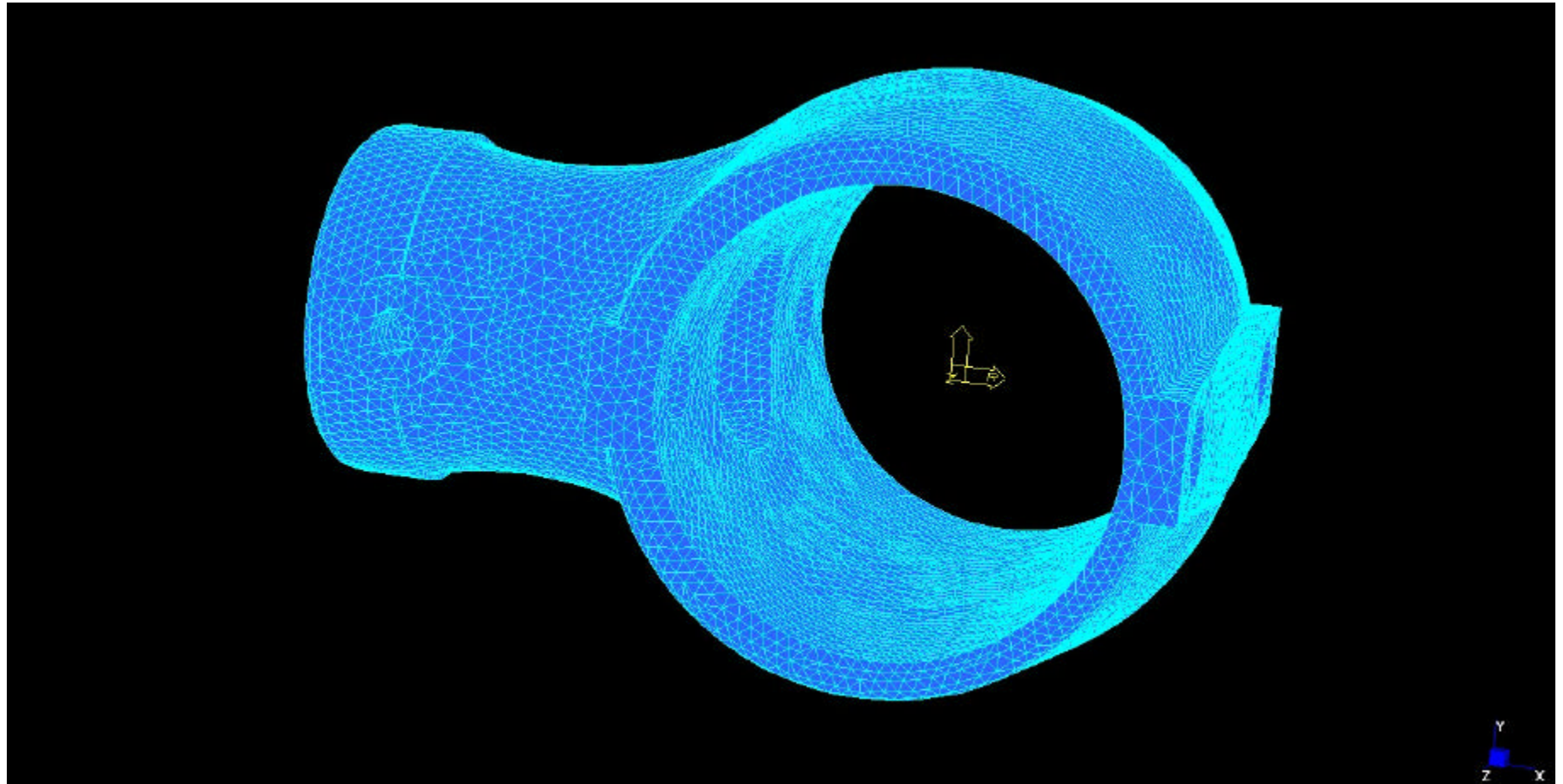
3D Model



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

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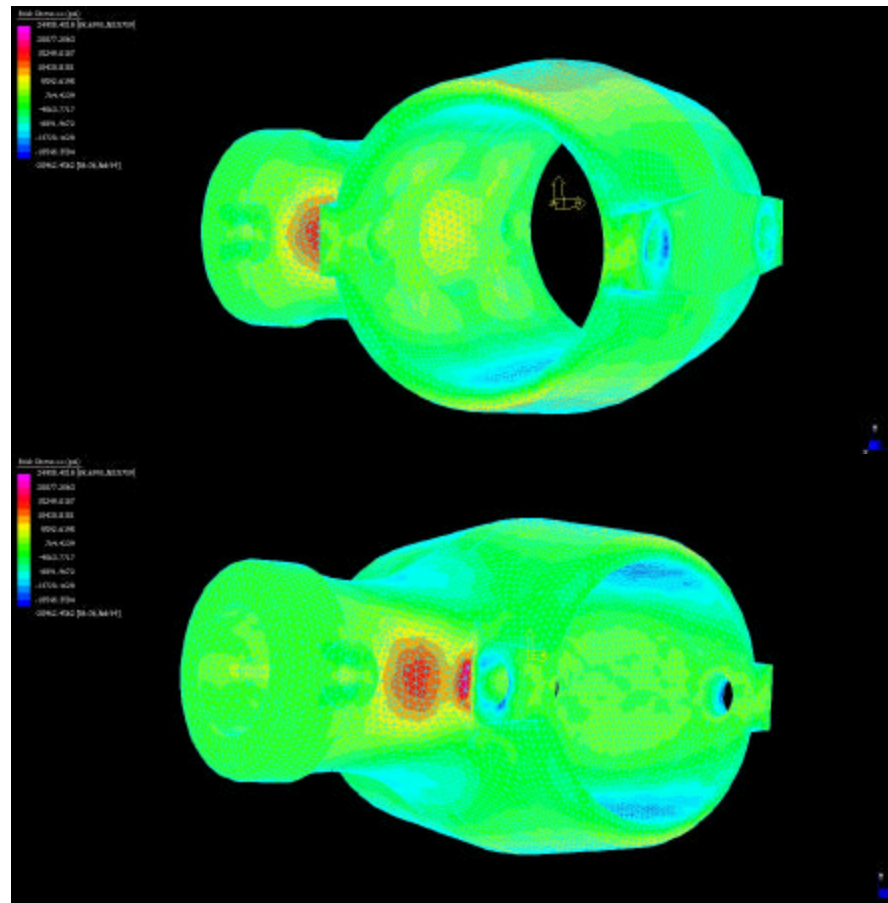
Strand 7 FEA Model





Strand 7 FEA Model – Installed Condition

XX Stresses
24905 psi tension
-20962 psi comp'n

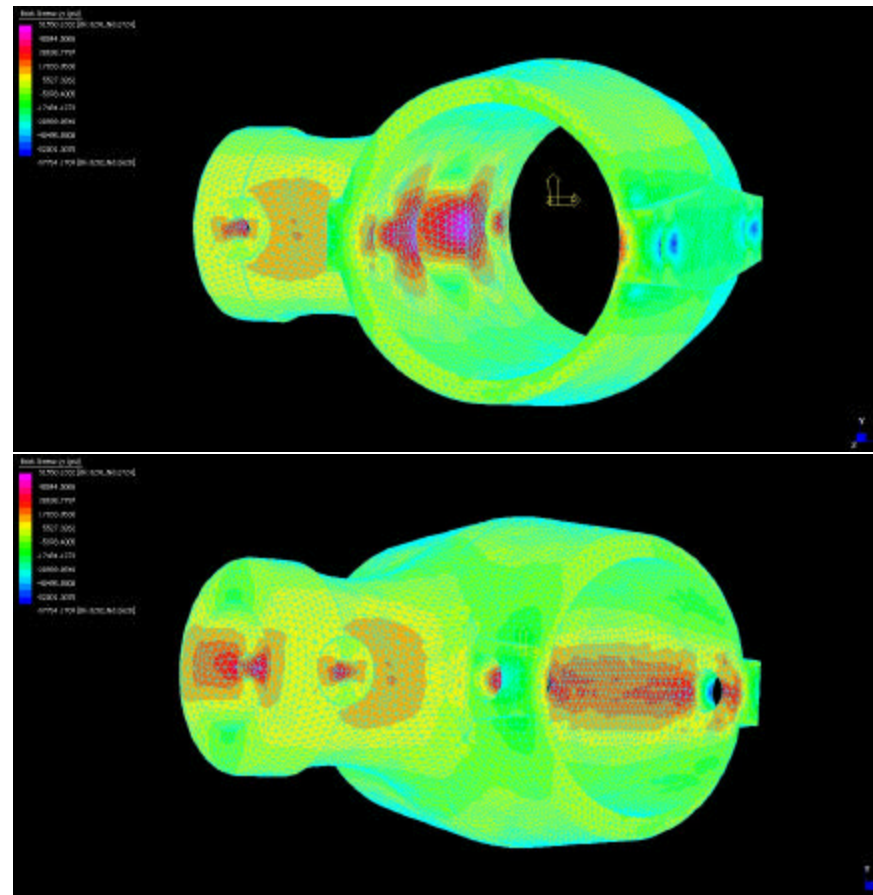


Notes: Installed condition is interference fit with counterbalance arm and bolt pre-load to torque tube.

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Strand 7 FEA Model – Installed Condition

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

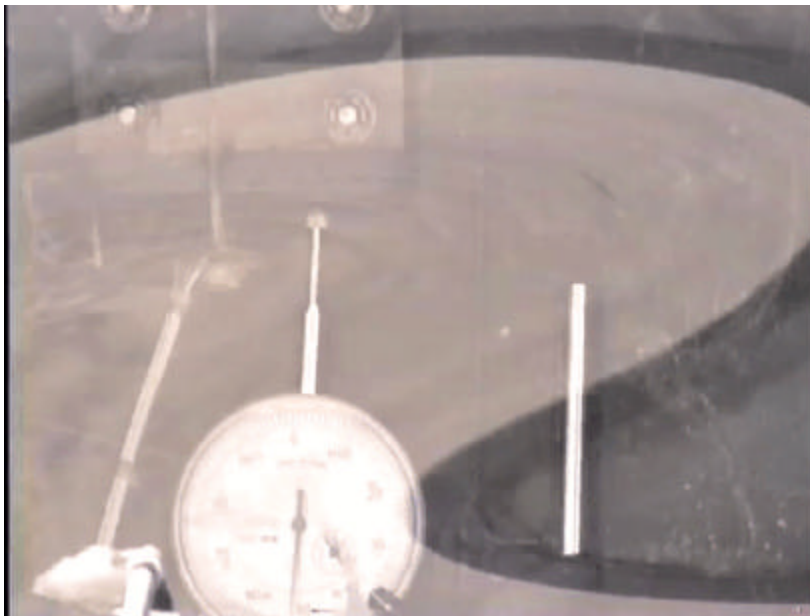


Notes: Installed condition is interference fit with counterbalance arm and bolt pre-load to torque tube.

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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



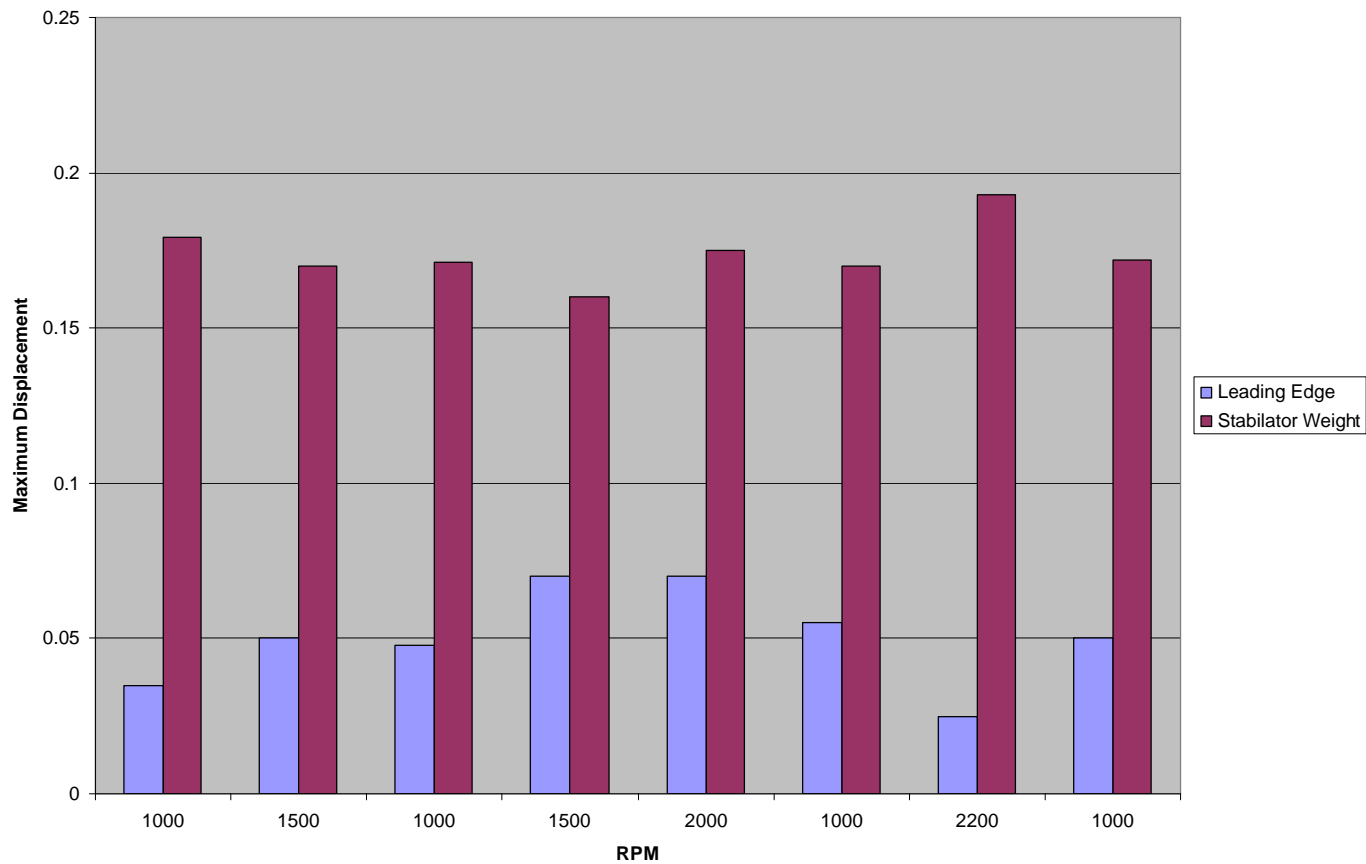
Notes: Brackets fabricated from aluminum sheet to support 5 KHz AC LVDT's measuring stabilator leading edge and counterbalance weight motion. Output to oscilloscope not successful. Data taken from digital displays (~.5 Hz refresh rate).



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LVDT Data

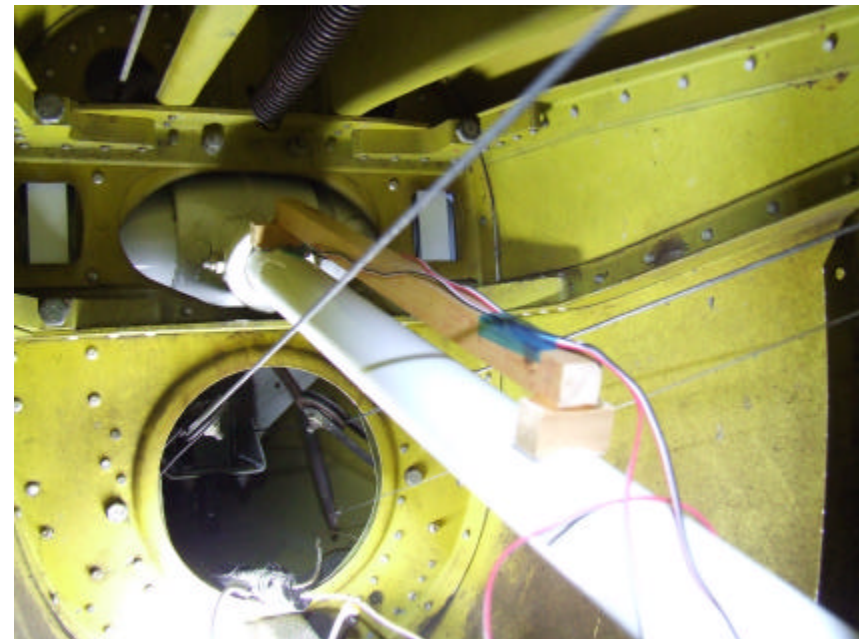
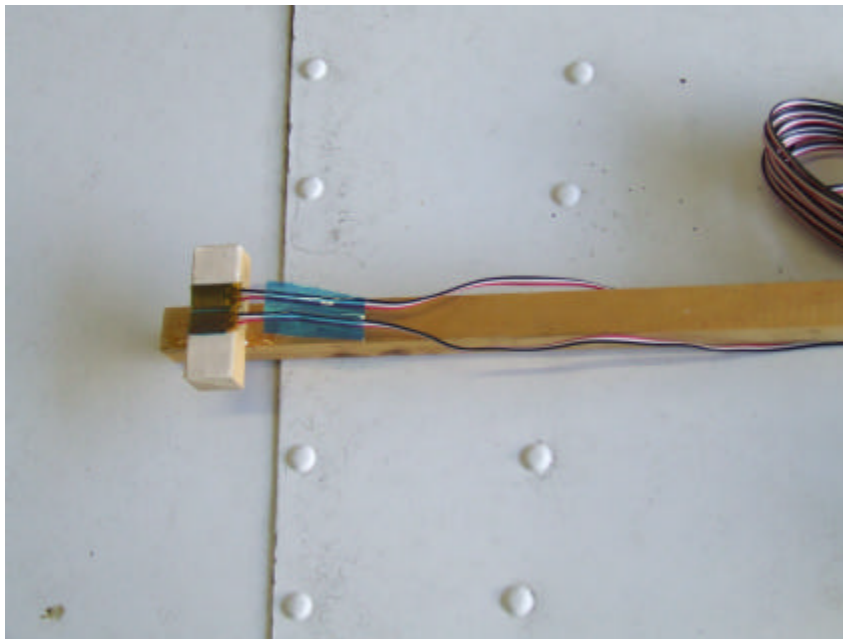
LVDT Data from Digital Readout



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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.



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 (330) 484-4609
- Technical Contact
 - *Hans Neubert, Technical Committee*
 - Hdneubert@sbcglobal.net (714) 998-1365