Comanche Torque Tube Corrosion Investigation

RESPONSE TO FAA SAIB CE-04-88
AND PIPER SERVICE LETTER 1160
14 July 2007
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Corrosion and the SAIB

- SAIB CE-04-88 issued on Piper PA 23,24,30,39 on September 15,2004
- The directive is advisory, not mandatory
- Recommends inspection of torque tube, attachment fittings, and attaching fasteners at 500 hour intervals
- The SAIB is the result of a letter by the ICS Technical Advisor to the Atlanta ACO
  - NOTE: The ICS Technical Advisor noted in the SAIB is Mike Rohrer, Altus Aircraft Repair Services. Mr. Rohrer's misrepresentation of himself to the FAA as the Technical Advisor caused considerable turmoil within the ICS community.

How Did This Happen

- FAA maintains two different databases of Service Difficulty reports
  - On the SDR data base, 7 cases of torque tube corrosion found dating back to Jan 1995
  - On the ASAP data base, 45 cases of torque tube corrosion found dating back to Jan 1974
  - On the ASAP data base, 19 of the 26 recent reports were submitted by Mr. Rohrer
- FAA reviews Service Difficulty Report Form 8010-4 for airworthiness and maintenance problems with possible corrective action (AD's)

Torque Tube Background Data

- Corrosion has been observed between the torque tube and the attaching bolts
  - Piper Service Letters 667A and 772
  - Advisory Directive 74-13-10 issued by FAA
- Inspection requires replacement of existing attaching stabilator bolts with corrosion resistant bolts
  - Replacement of bolts with CRES bolts is terminating action of the AD

Action Plan

- Fearing that a potentially devastating AD could result from the SAIB, action included:
  - Testimonial letters responding to SAIB from 9 recognized Comanche specialty repair facilities
  - Initiated owners survey of inspection results on both the Delphi and ICS site
  - Received from Altus an unserviceable torque tube assembly for structural load testing

Testimonial Letter Summary

FACILITY	REPRESENTATIVE	FINDINGS OF CORROSION
Webco Aircraft	Bob Weber	"I have reviewed SAIB #CE-04-08 and have never encountered anything remotely similar to what these pictures show"
Aircraft Engineering, Inc.	Bill Turley	"In some instances, some corrosion found, but never to the extent displayed in the SAIB"
Iliff Aircraft Repair & Service	Charles Iliff	"We have never found any serious amount of corrosion"
Johnston Aircraft Service	Dave Johnston	"We have never seen, experienced or heard of the amount of corrosion shown in the pictures accompanying the SAIB"
Clifton Aero	Tim Talley	"We have not found on our inspections, the severe rust pits [shown in the SAIB] on the O.D. of the stabilator torque tube"
Penn-Air Inc.	Dan Claycomb	"We find corrosion, but none that could be considered unairworthy"
Liebfried Aviation Inc.	Andy Liebfried	"The difficulty in a re-occurring inspection is that disassembly will provide more damage at the hands of inexperienced technicians than a quality process and treatment for the tube on a one time or long term inspection basis"
Swift Aviation Services	August Mazzella	"We have never discovered as extensive corrosion as depicted and feel that, as repetitive an inspection would be unnecessary and may cause more damage to the area, outweighing the benefit"
Squire Aircraft, Inc.	Bob Squire	"While doing an annual inspection I always check all components of the empennage and I have not found any evidence of corrosion on the torque tube as pictured in SAIB CE-04-08

Initial Survey Results

- Initial survey results from the ICS site and from data submitted by Dale VanDever:
  - 42% - No Corrosion Found
  - 24% - Minor Corrosion Found and Mitigated
  - 1% - Significant Corrosion Found and Mitigated
  - 8% - Corrosion Found on Bolts only & replaced
  - 25% - Have not performed inspection yet
- Initial summary from 203 inspections performed
  - NOTE: Survey response rather dismal considering potentially devastating future AD

Samples of Torque Tube & Bolt Corrosion

Typical Severe Corrosion On Torque Tube

Typical Corrosion on AN5 Bolt Holding Horn to Torque Tube

Samples of Torque Tube Corrosion

Torque Tube Test Specimen

- PA 24-250 unserviceable unit received from Altus
- Torque Tube cleaned up using 180 grit media
- Precise measurements made after clean up
- Coated with zinc chromate and paint
- Adapter fittings, load reaction fittings and base plate fabricated for structural testing of complete Torque Tube assembly

Initial Condition

RHS as received

LHS as received

Torque Tube deemed unserviceable by Altus

Surface Pitting after Cleanup

Torque Tube Measurements

Horizontal Stabilator Investigation - Torque Tube Measurements			
Diameter - LHS - Outboard Parallel/Normal to Bolt Holes	Diameter - LHS - Inboard Parallel/Normal to Bolt Holes	Diameter - RHS - Inboard Parallel/Normal to Bolt Holes	Diameter - RHS - Outboard Parallel/Normal to Bolt Holes
Parallel: 2.3106	Parallel: 2.3123	Parallel: 2.3112	Parallel: 2.3107
Normal: 2.3112	Normal: 2.3091	Normal: 2.3100	Normal: 2.3111
Ave: 2.3109 ± .0003	Ave: 2.3107 ± .0016	Ave: 2.3106 ± .0006	Ave: 2.3109 ± .0002
	Overall Tube Diameter Measurement: 2.3108 ± .0016		
Per Piper Drawing - Outside Diameter = 2.3115 inches +.0003 / -.0002			

Vne vs. Weight by Model

Comanche Data from TCDS			
Model	**Vne Speed (CAS)**	**Gross Weight***	**Forward CG Limit**
24-180	202	2550	89
24-250 (Note 1)	203**	2800	87.7
24-250 (Note 2)	203**	2900	86
24-260 (Note 3)	203**	2900	86
24-260 (Note 4)	203**	3100	88.4
24-260 (Note 5)	203**	3200	89.6
24-400	250	3600	84.8
30	230	3600	86.5
39	230	3600	86.5
Note 1: S/N 24-1, 24-103 through 24-2298, except 24-2003			
Note 2: S/N 24-2003, 24-2299 through 24-3687			
Note 3: S/N 24-3642, 24-4000 through 24-4246, and 24-4248 through 24-4299			
Note 4: S/N 24-4247, 24-4300 through 24-4782, and 24-4784 through 24-4803			
Note 5: S/N 24-4783, and 24-4804 through 24-5034 (normally aspirated engine only)			
Special Notes:			
*** Data does not account for gross weight changes per STC modifications**			
**** Vne increased to 227 mph when both Piper Kits 760-705 and 760-747 installed**			

Load Condition Selection

- Select symmetrical pull-up at forward CG at 227 mph CAS (Vne)
  - Largest tail down load is 2000 lb and 5.9” fwd cg (24-260)
  - Tail Down Load = 1753 lb at 3.8g Design Limit Load
  - Moment & Shear satisfied at 42% semi-span
- Torque Load from CAR3/Part 23
  - Maximum control wheel pull load = 200 lb
  - Torque = 5600 in-lb at 3.8g Design Limit Load
- Bending and Torque Conditions Combined
  - Load is offset from Torque Tube centerline by 3.2 inches
  - Load Condition covers all single models (except 400’s)

Test Spectrum Selection

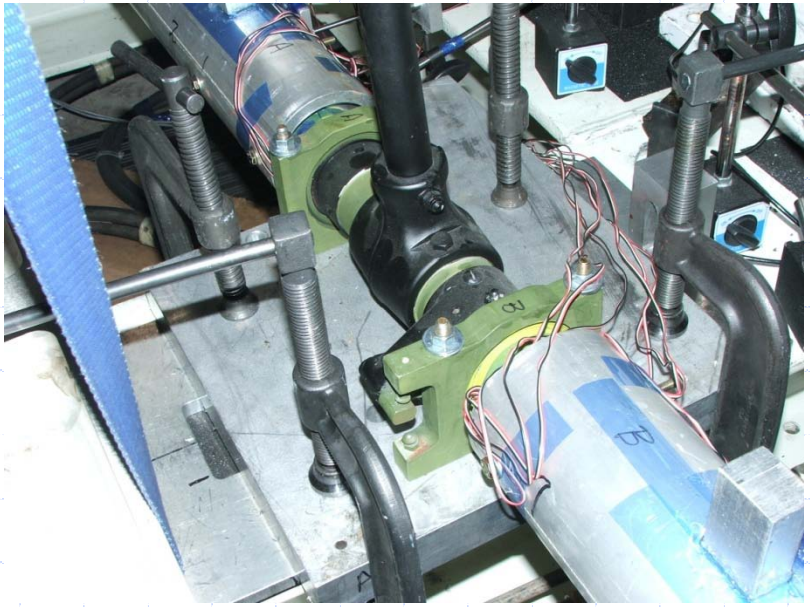
- Load Set 1: 0 ->3.8g->0 in 20% increments
- Load Set 2: Cycle 100x to DLL (3.8g)
- Load Set 3: 0 ->5.7g->0 in 20% increments

  - Note: Load, strains, displacements all captured simultaneously

Strain Gaged Specimen

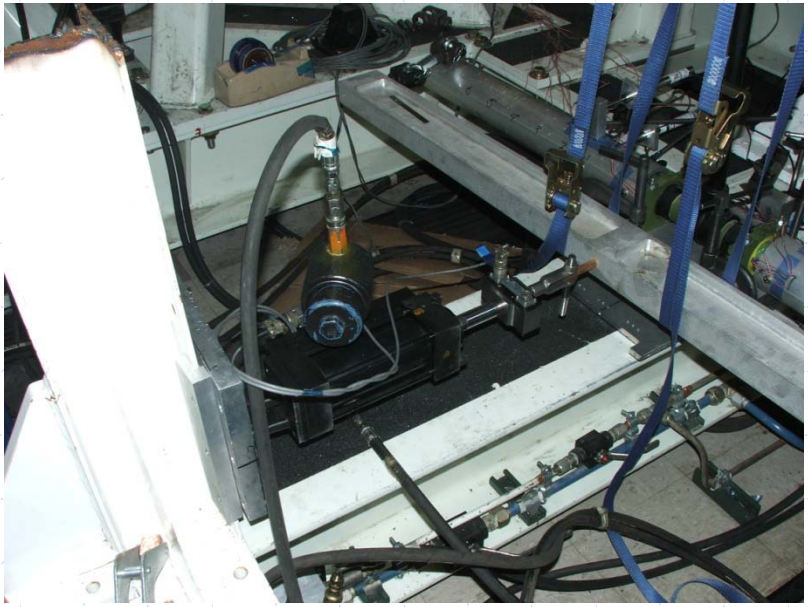
Aluminum collars represent yoke fittings in stabilator. 12 strain gages employed representing bending and torsion loading results for each side of torque tube.

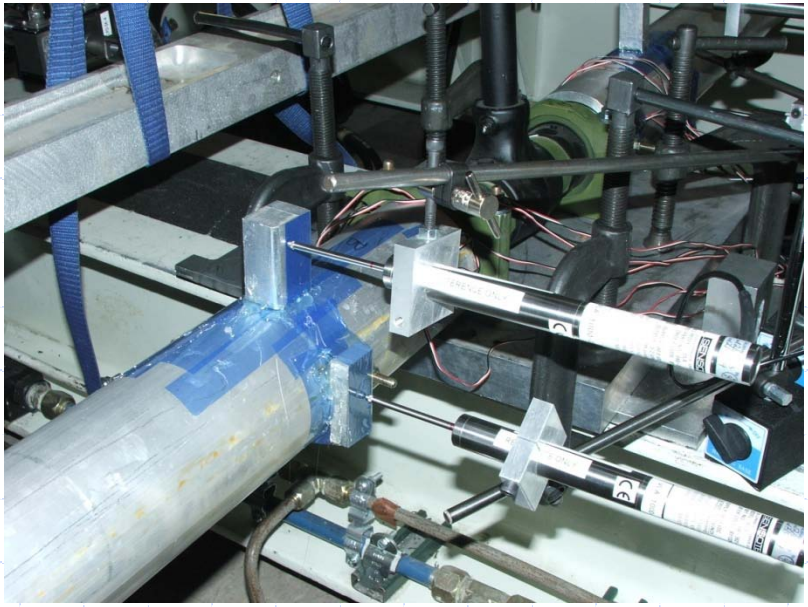
Test Setup



Torque tube assembly is loaded vertically in test frame. Bearing blocks bolted to aluminum plate and clamped to 12” I beam. Large beam is used to load assembly both sides simultaneously.

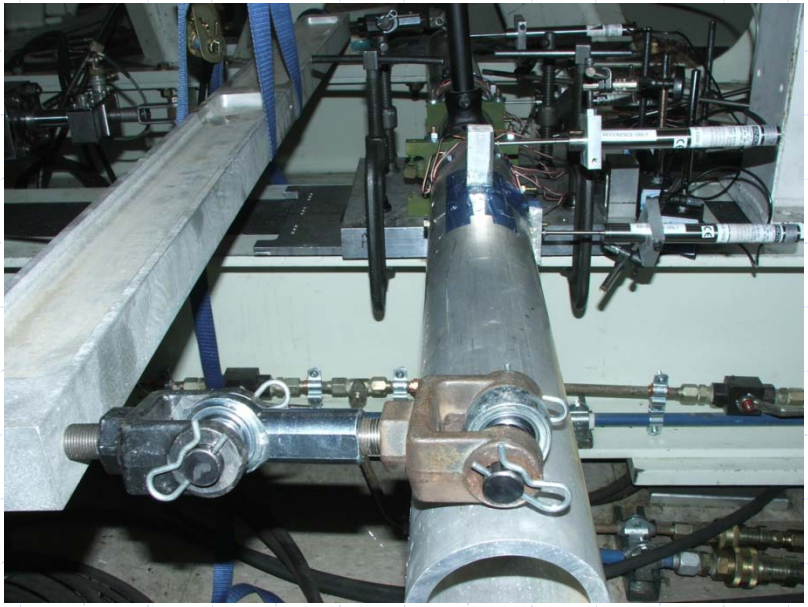
Test Setup





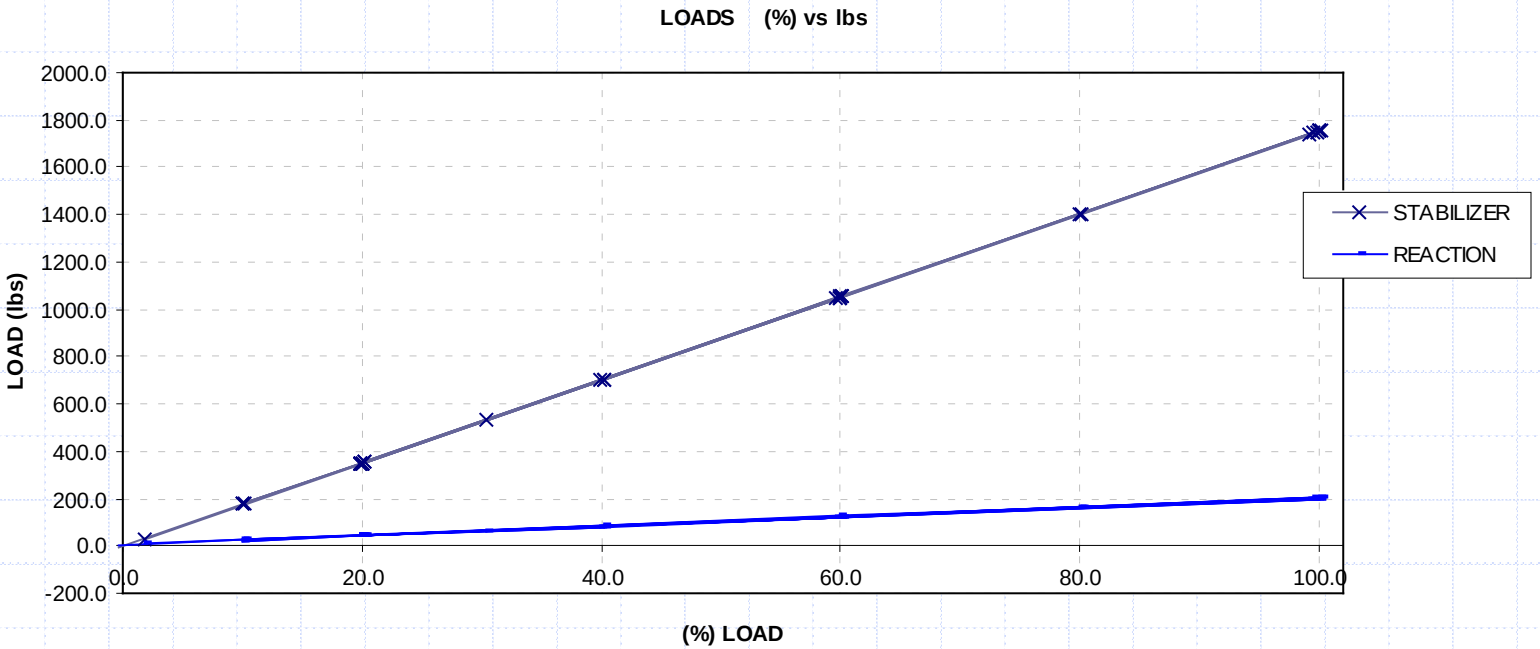
Servo controlled hydraulic cylinder with load cell LHS. Blue straps float the weight of the lateral beam. Small cylinders (RHS) are displacement LVDT's

Test Setup



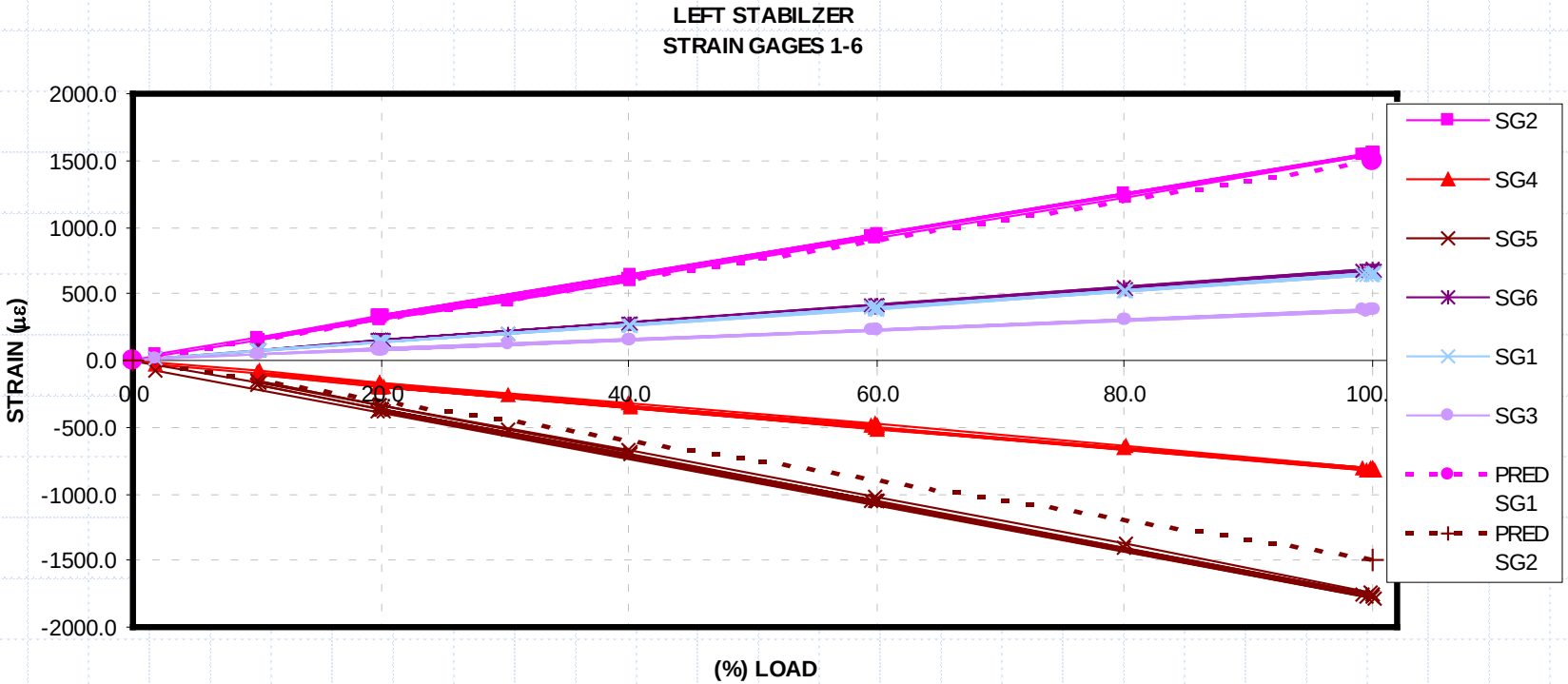
Load beam attaches to thick tube through link and bearings. Load cell reacts loading at the cable attachment point through a load cell.

Load Case 1 Load



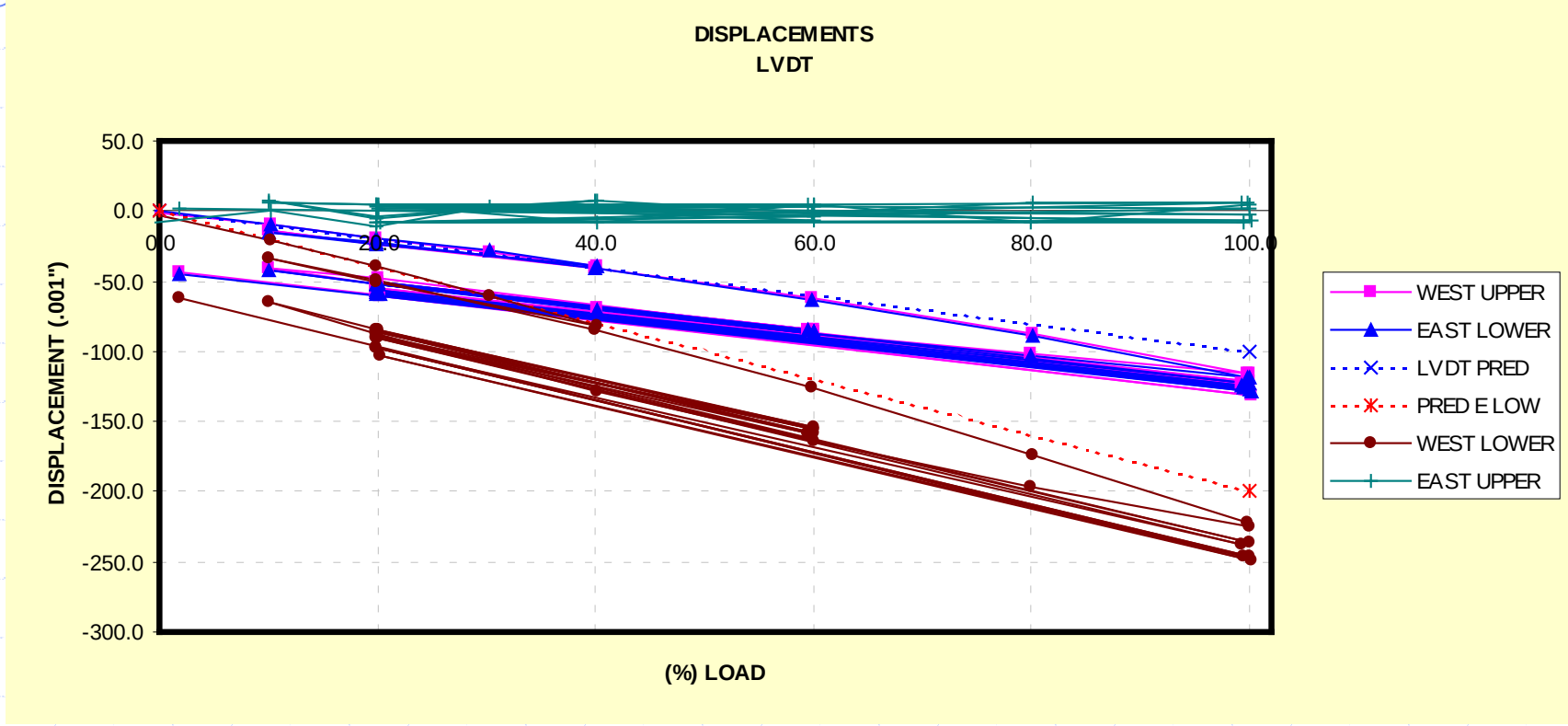
At 1760 lb on torque tube, reaction at counterbalance tube is 200 lb. All linear response.

Load Case 1 Strain Data



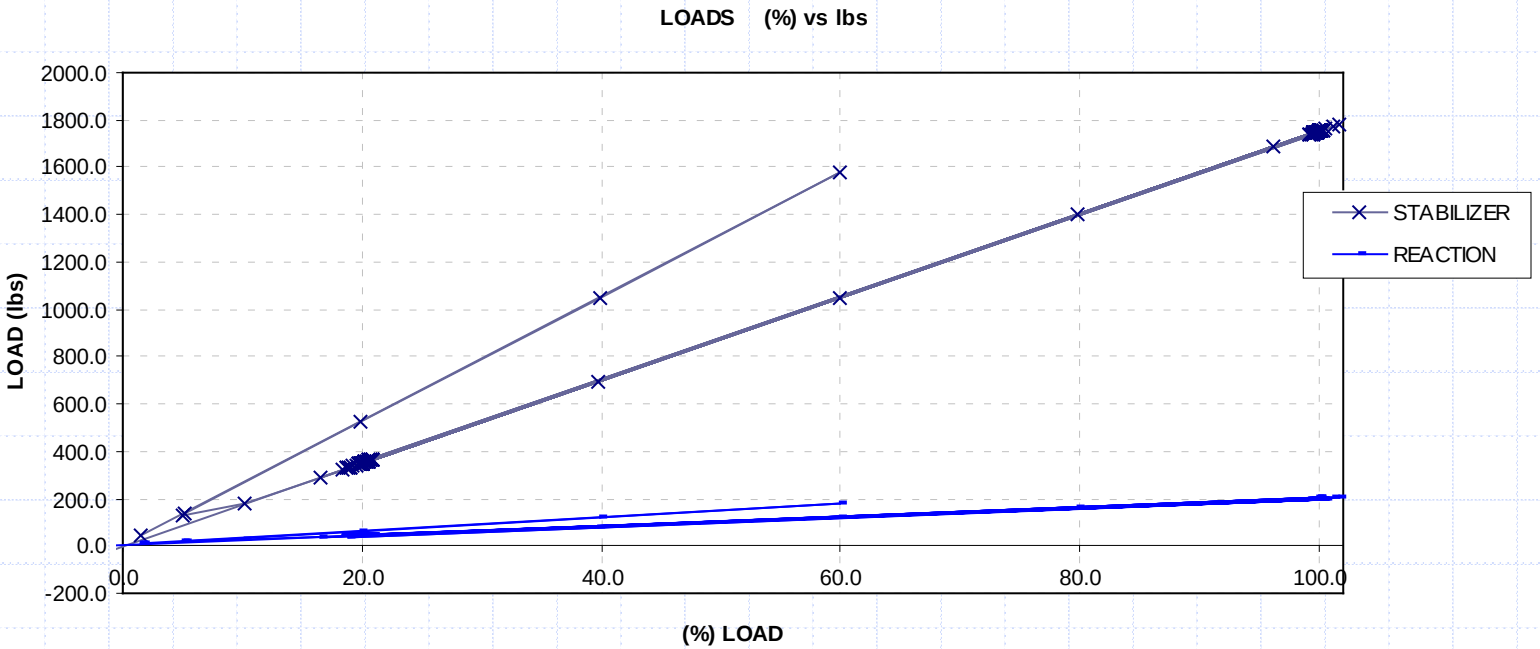
Measured strains on torque tube. Bending stress = 27.5E6 * strain = 27.5E6 * .001525 = 41,938 psi.

Load Case 1 Displacements



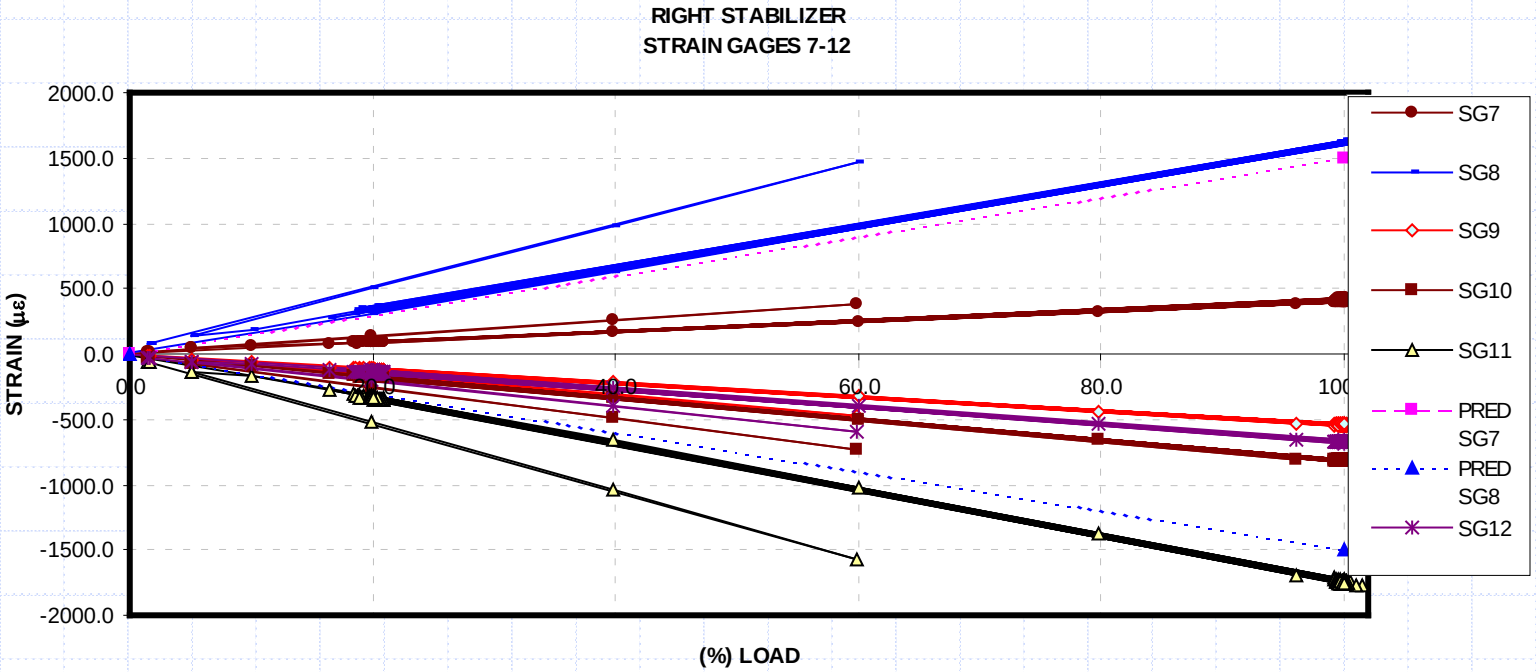
Largest displacement at edge of torque tube = .250”

Load Case 2 Loads



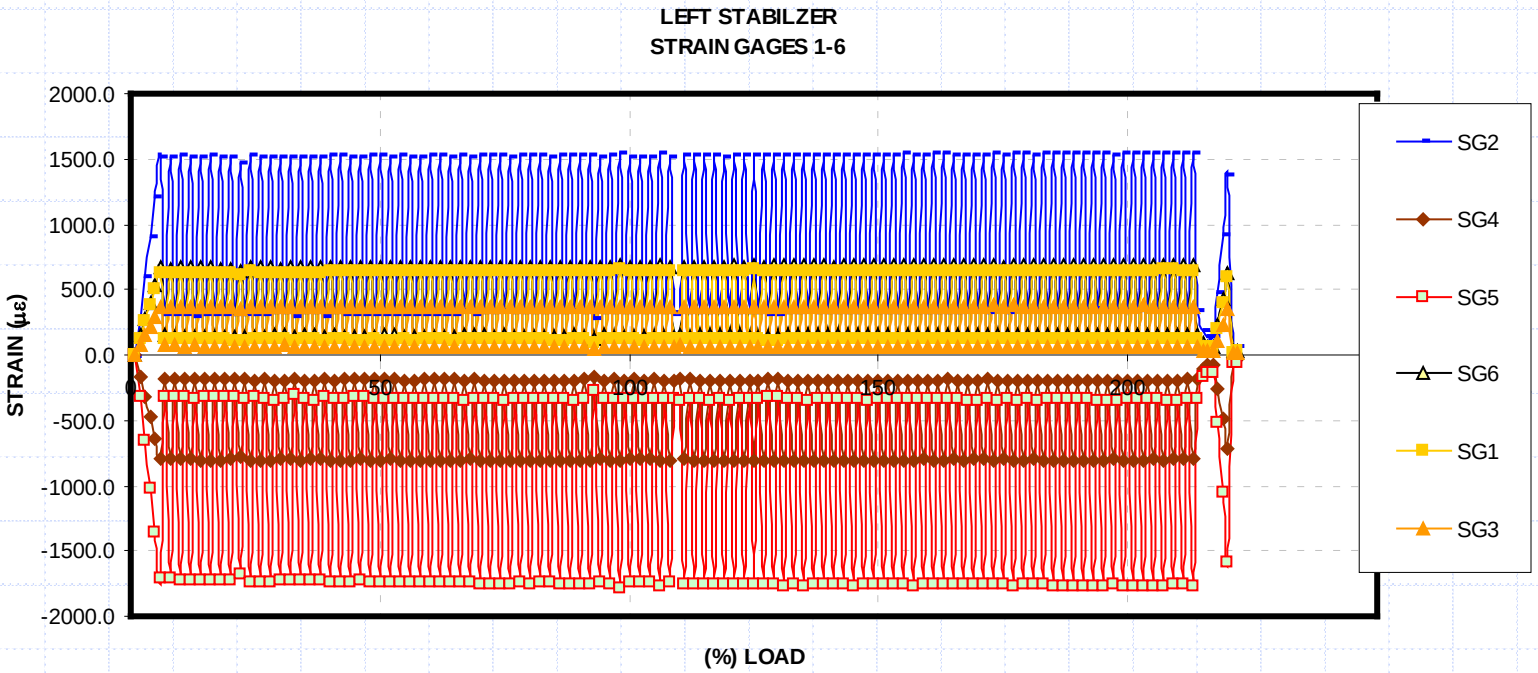
LC2 maximum load = 1800 lb, reaction = 200 lb.

Load Case 2 Strains



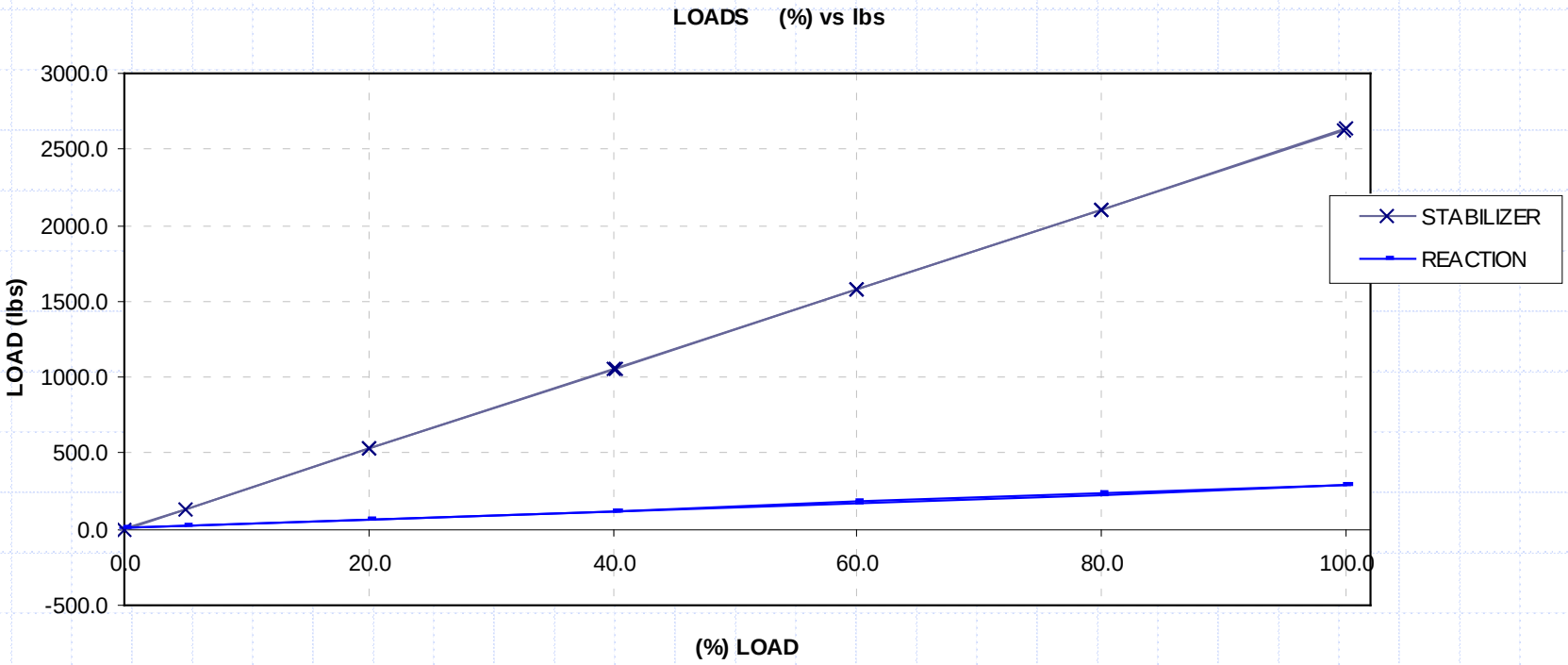
1st Cycle of LC2 – Results similar to LC1 at 3.8g loading.

Load Case 2 Strains



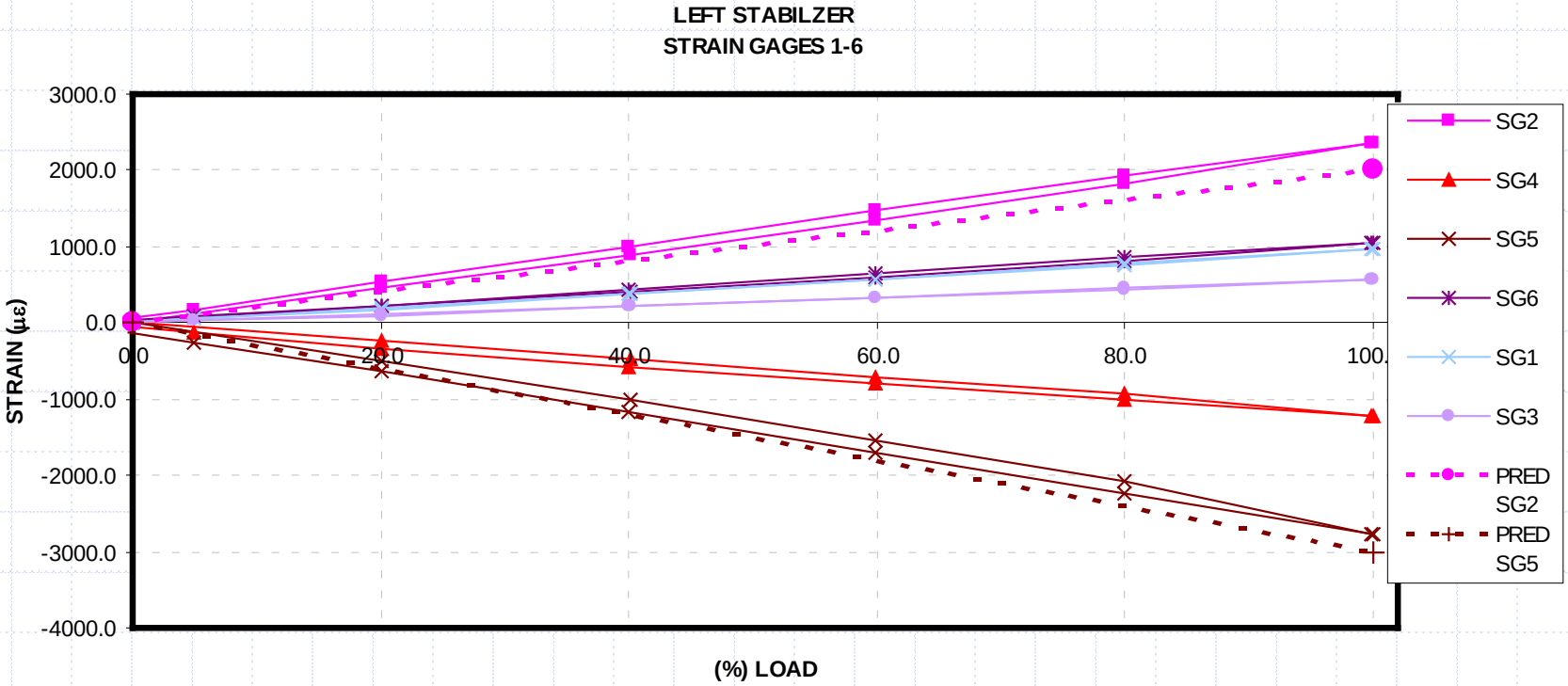
Actual number of cycles to DLL (3.8g) is 105.

Load Case 3 Loads



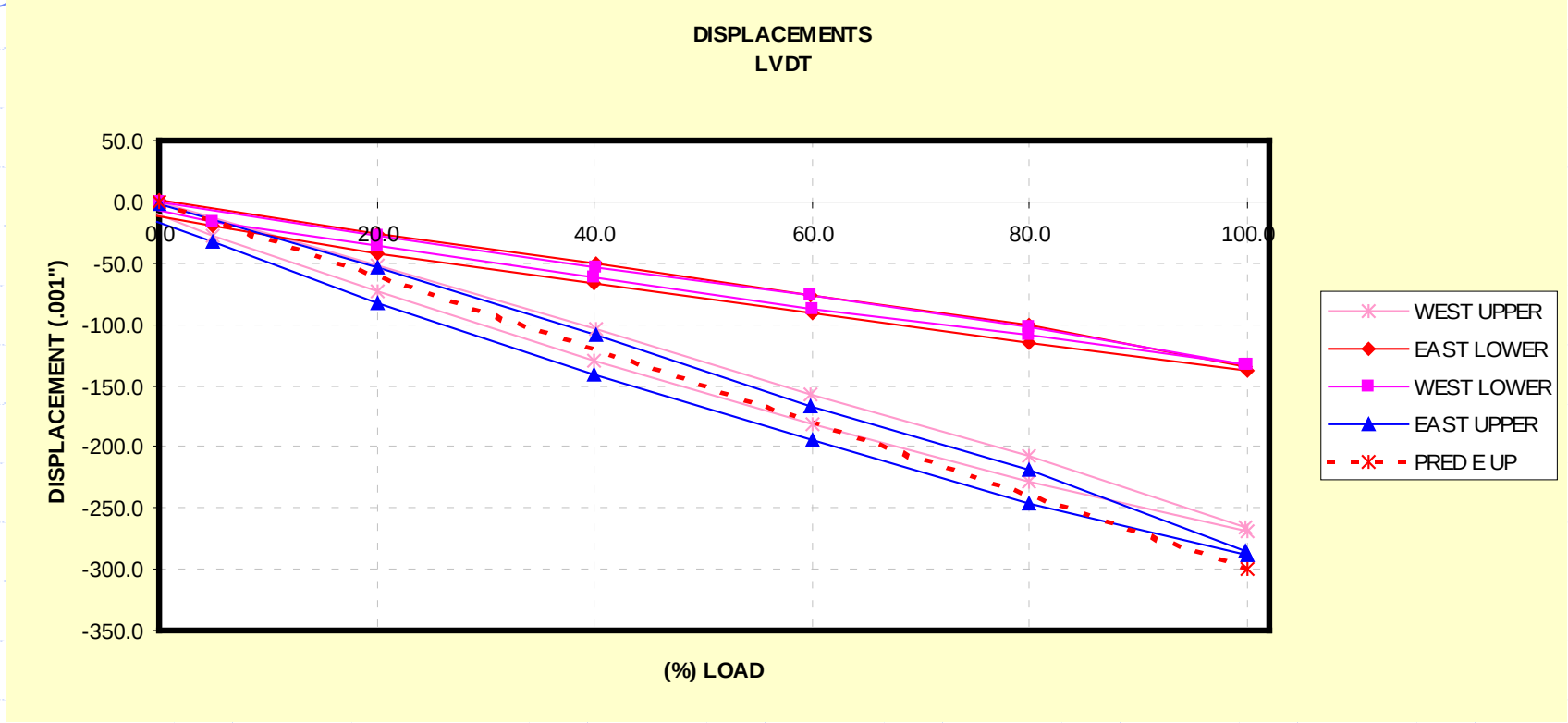
LC3 is ultimate load DUL (5.7g) with 2625 lb applied and 300 lb reaction.

Load Case 3 Strains



All strains are still linear at ultimate load.

Load Case 3 Displacements



All displacements are linear at ultimate load.

Summary

- An unserviceable torque assembly was re-furbished and life cycle tested to DLL, and subsequently to DUL.
- Strain and displacement measurements show that during the life cycle testing, the torque tube exhibited linear, elastic characteristics.
- Corrosion on a torque tube, if found, is a Maintenance issue. These tests show conclusively that a corroded torque tube is not an Airworthiness issue.

Conclusions

- SAIB CE-04-88 is now replaced by Piper Service Letter 1160
  - The Service Letter is not mandatory for Part 91
  - The Service Letter requires torque tube inspection at 10 year intervals
- A corroded torque tube is shown to be Airworthy by testing conducted herein
- The Atlanta ACO has no intentions of issuing an AD on the torque tube based on SL 1160 As a result of this testing, torque tube corrosion is considered a maintenance issue.