



CUSTOMER SATISFACTION VS. TIE ROD LASH

**A DRIVER SURVEY TO
DETERMINE 90TH PERCENTILE
SENSITIVITY**

Powers & Sons
Division of Letts Industries



Why Do This ?

- GOAL OF 10 YR/150,000 MILE JOINT
 - PRIMARY HIGH MILEAGE FAILURE MODE IS LASH. SYMPTOMS INCLUDE:
 - NOISE
 - STEERING “LOOSE”
 - TIRE WEAR
 - WHO IS OUR 10YR/150,000 CUSTOMER?
 - DRIVER
 - ALIGNMENT RACK
 - MECHANIC



Project Goals

- DETERMINE AMOUNT OF LASH DETECTABLE TO A 90TH PERCENTILE DRIVER
 - ONE SIDE LOOSE VS. BOTH SIDES LOOSE
- EVALUATE DEMOGRAPHICS OF 90TH PERCENTILE DRIVER

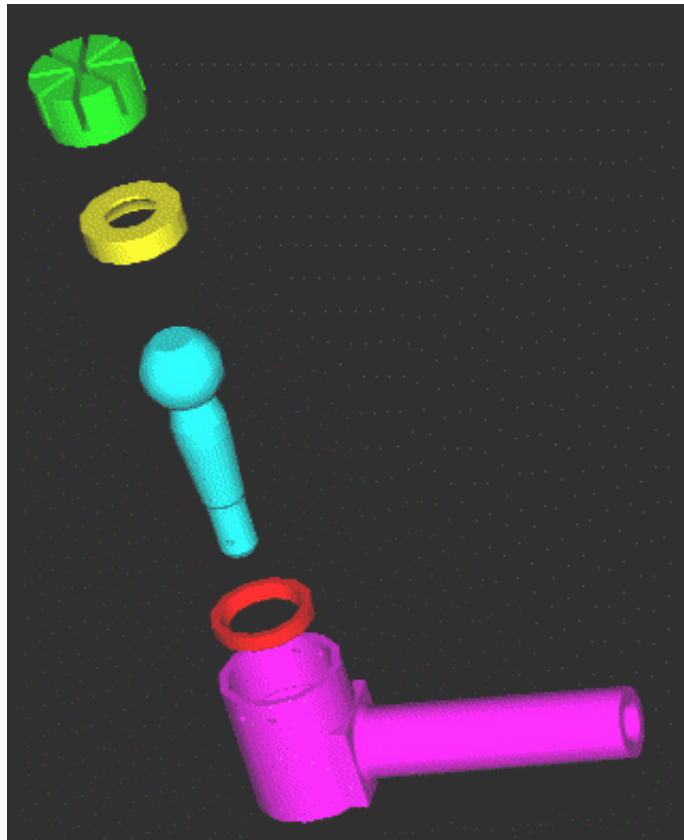


Project Goals

- DETERMINE AMOUNT OF LASH DETECTABLE ON AN ALIGNMENT MACHINE
- DETERMINE AMOUNT OF LASH DETECTABLE TO AN ASE MECHANIC



Design of the Joint



- Design Specifics
 - 26mm Ball Stud
 - Adjustable Cap
 - Nylon Upper and Lower Bearings



Adjustable Lash Joint



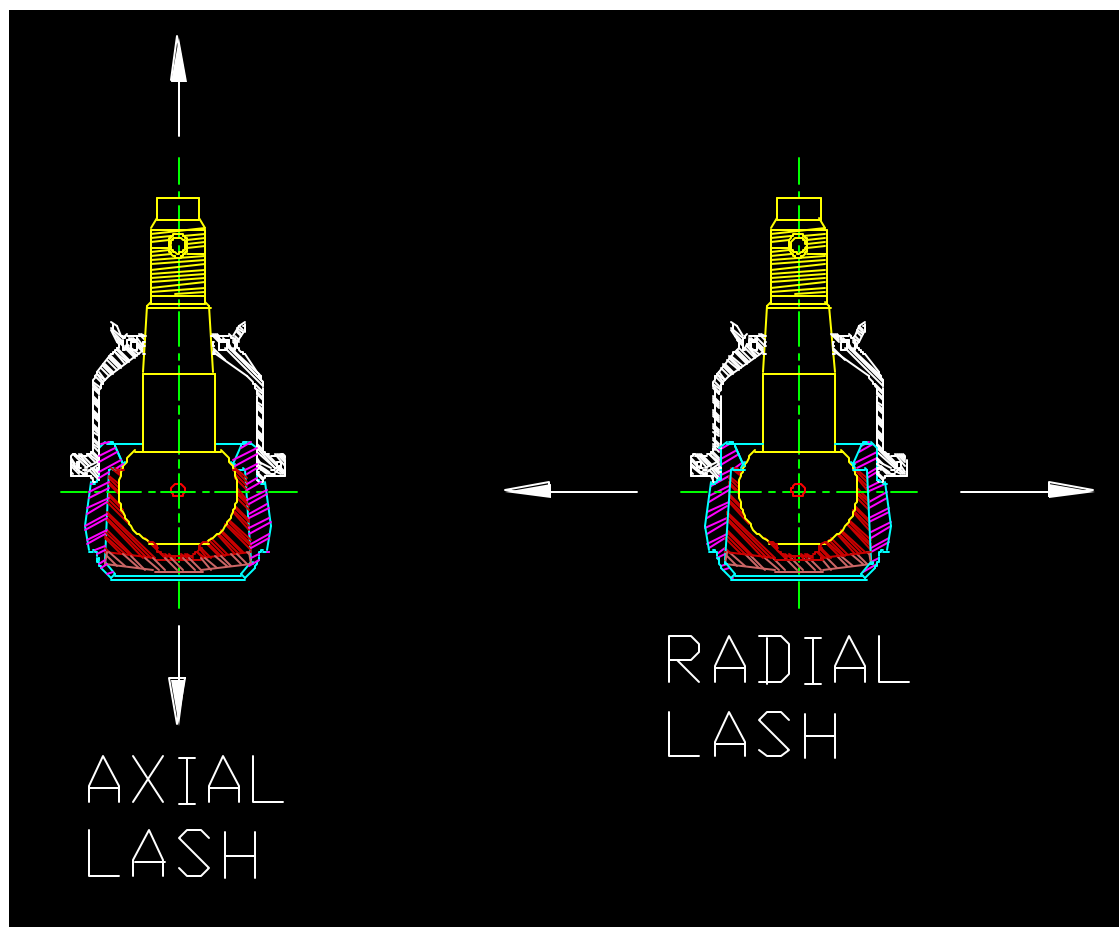


LASH VS COMPLIANCE

- LASH IS FREE MOVEMENT UNDER NO LOAD
- COMPLIANCE IS RELATIVE MOTION UNDER LOAD
- COMPLIANCE PICKS UP LASH
- LASH DOES NOT PICK UP COMPLIANCE
- CUSTOMERS SPECIFY COMPLIANCE

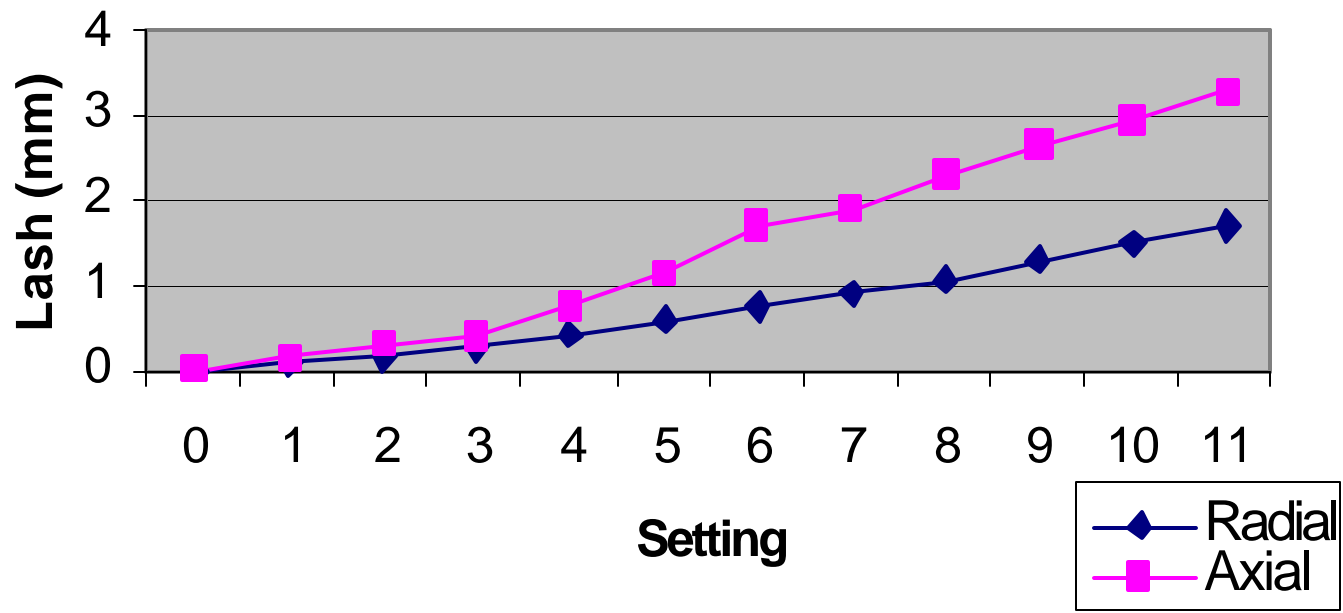


AXIAL VS RADIAL LASH



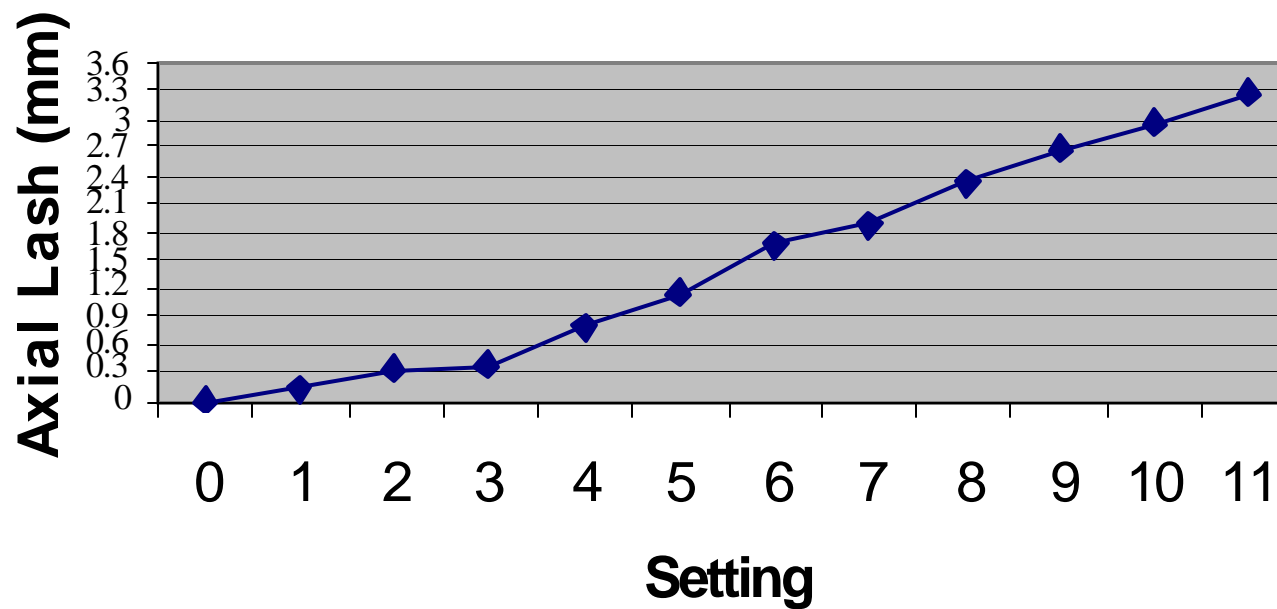


Axial and Radial Lash vs. Setting



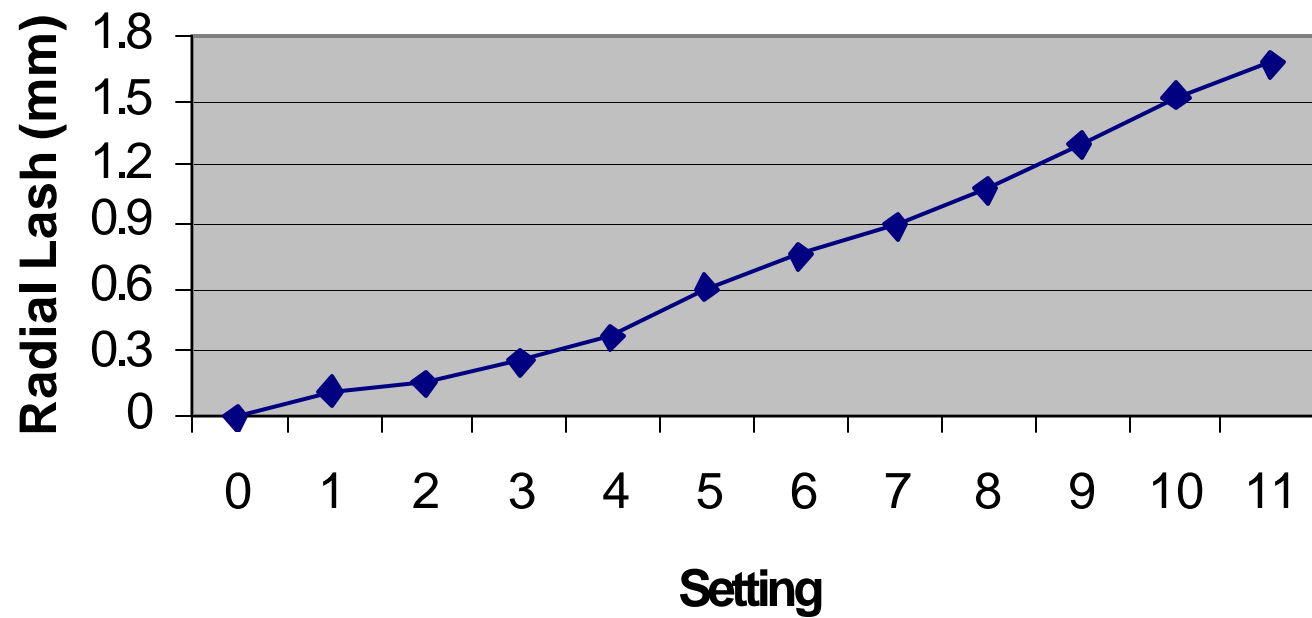


Axial Lash vs. Setting



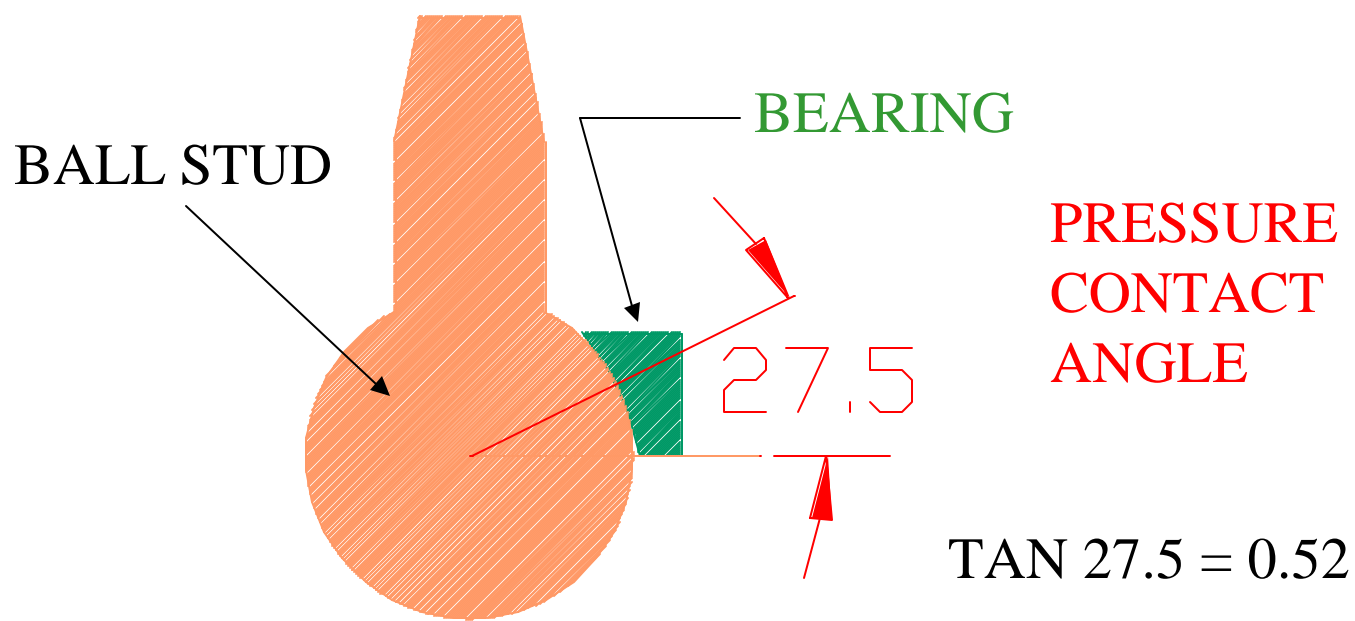


Radial Lash vs Setting





Relation of Axial to Radial Lash





Testing

- Personal subjective test drive (1999 Ford Taurus @ 40,000 miles)
- Alignment machine testing
- Subjective mechanic evaluation



Test Drive Procedure

- 1. The ball joint is set to a known amount of lash.**
- 2. The evaluator then drives the car on a predetermined route including rough roads and highway driving. Then when parked does a lock to lock steering cycle.**
- 3. After the trip is completed. The evaluator is asked to fill out a form concerning differences felt in the car. While the evaluator is completing the survey, a Powers & Sons attendant will make an adjustment to the ball joint.**
- 4. The same predetermined course is driven with the new adjustments with the changes being noted by the customer. This process is repeated several times.**

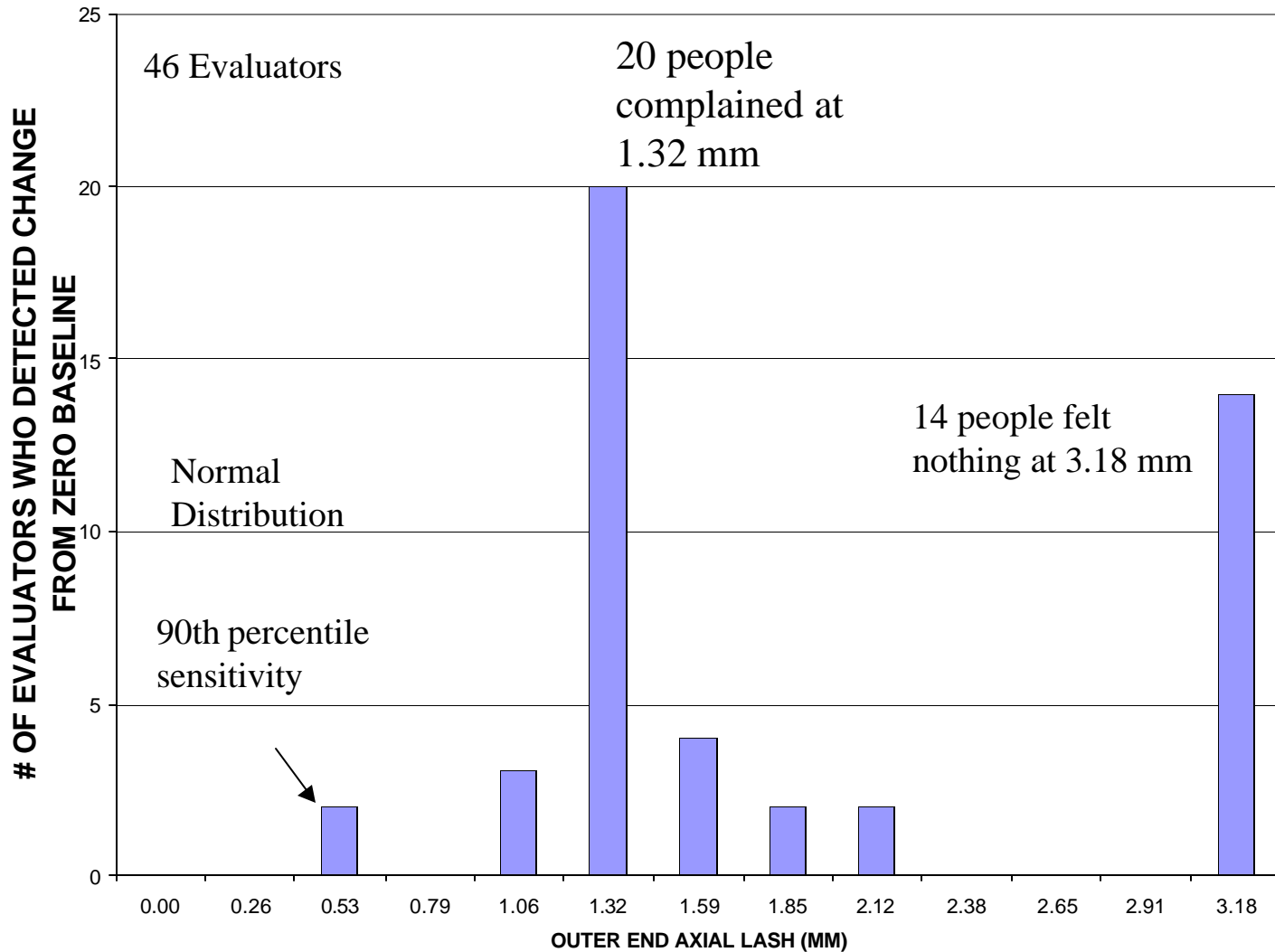


Test Drive Results

46 People Drove with one side adjusted

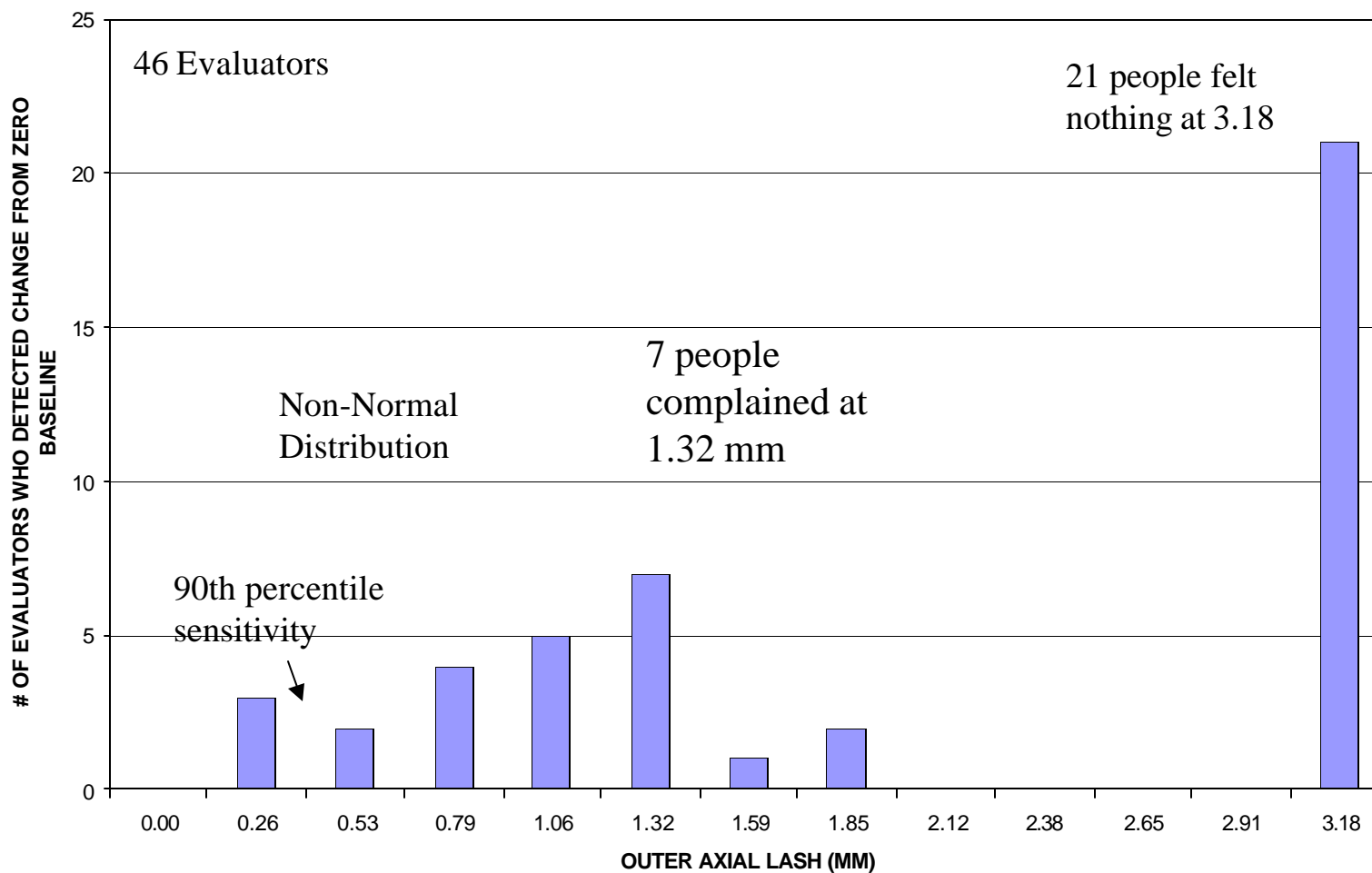


TIE ROD OUTER END LASH SENSITIVITY - DRIVE



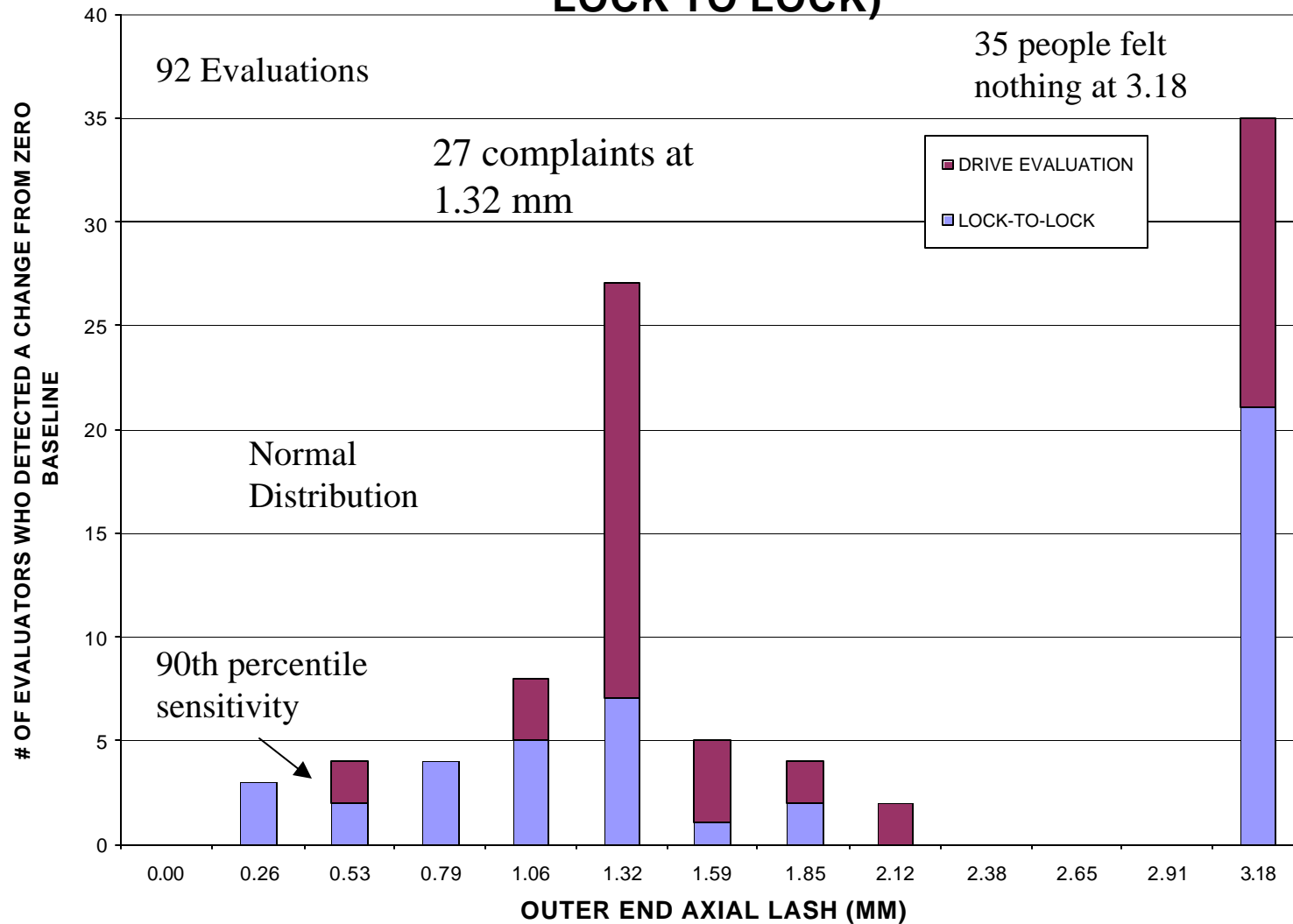


TIE ROD END OUTER END LASH SENSITIVITY LOCK TO LOCK





TIE ROD OUTER END LASH SENSITIVITY (DRIVE & LOCK TO LOCK)





Demographics

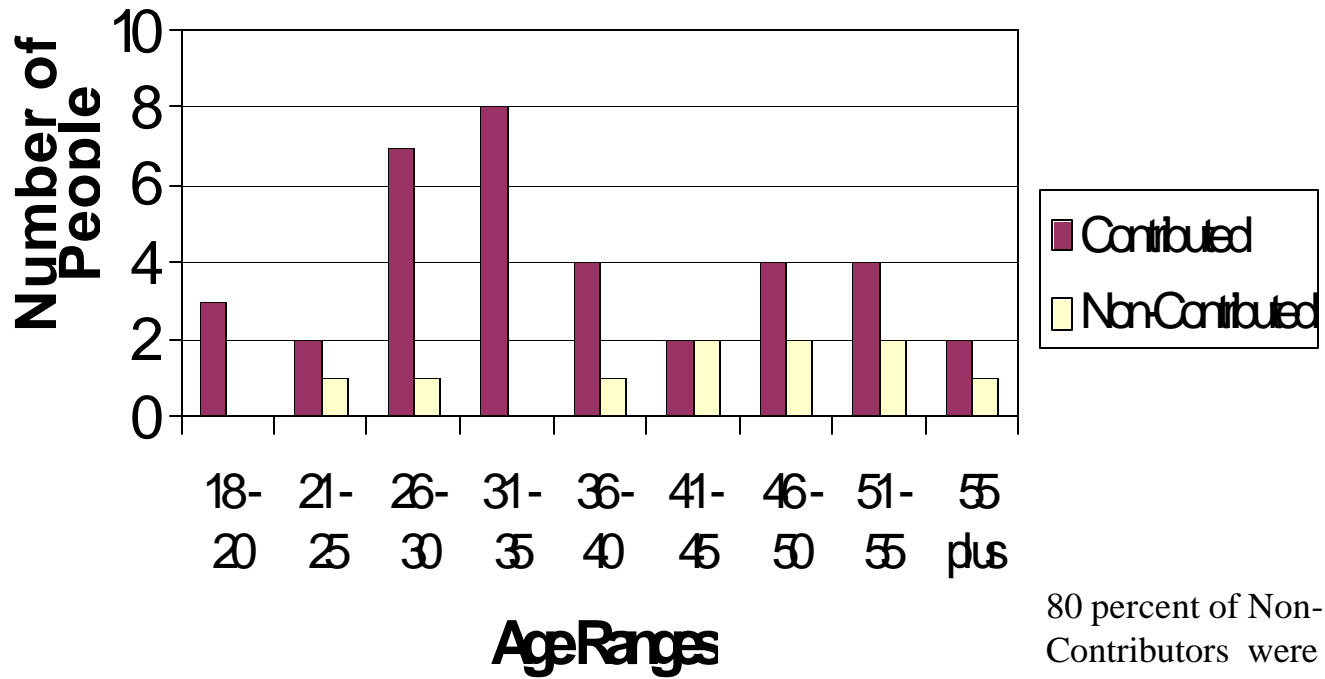
- 46 Total Drivers
- 35 Men vs. 11 Women
- 27 Engineers vs. 19 Non-Engineers
- 36 Contributors vs. 10 Non-Contributors
 - Contributor senses some change through full range
 - Non-contributor senses no change through full range
- Ages of drivers ranged from 18 to 63 with 38 being the average age



*Half less than
forty*

Half over forty

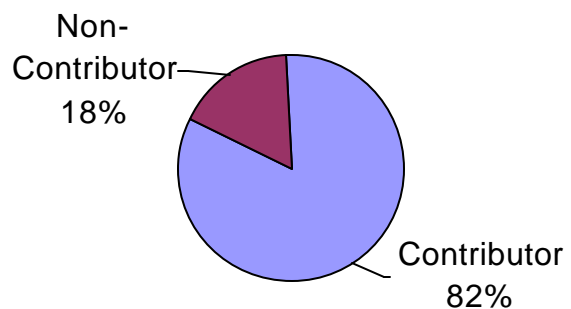
Age vs Contributor



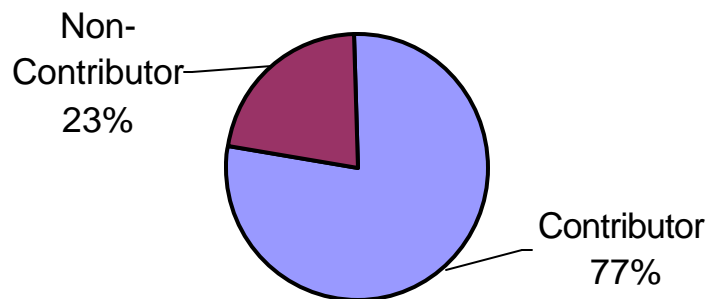
80 percent of Non-Contributors were over forty



Women Contributors vs. Non Contributors

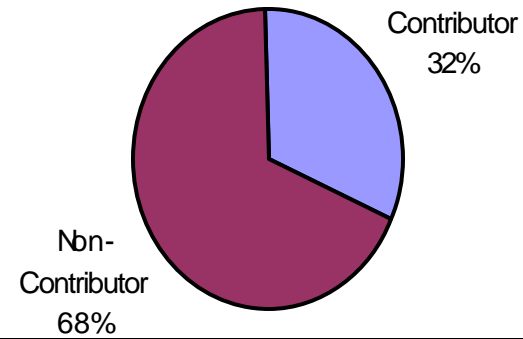


Men Contributors vs. Non-Contributors

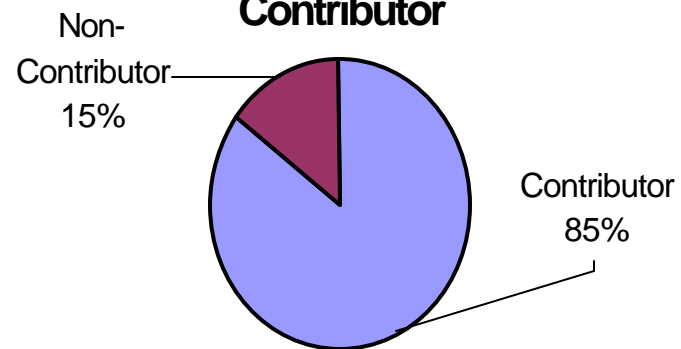




Non-Engineer Contributor vs Non-Contributor



Engineer Contributor vs. Non-Contributor





Demographic Conclusions

The optimum evaluator is an
Engineer under 40 (male or female)



Alignment Specifics

Test 1

- Measurements of Toe in/out (degrees) with *one* Adjustable Tie Rod End.
 - Measurements were taken after an adjustment was made.
 - This procedure was performed several times

Test 2

- Measurements of Toe in/out (degrees) with *two* Adjustable Tie Rod End.
 - Measurements were taken after both adjustments were made.
 - The same adjustment was made on both sides several times.

All tests were preformed by an ASE certified mechanics.

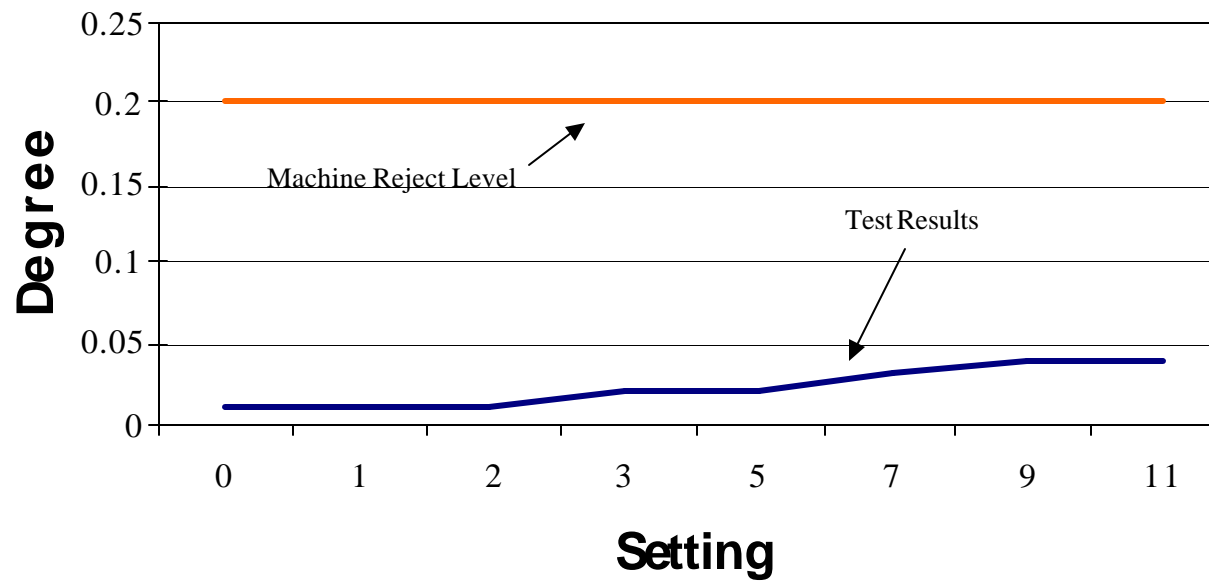


Alignment Machine Results

- At highest setting for lash the alignment machine didn't call it "bad"
- Maximum toe in/out found was .09 degrees
- Problems are found by the "poke and prod" method opposed to the Alignment machine
- ASE mechanic would consider part in need of replacement at 1.2 mm axial lash

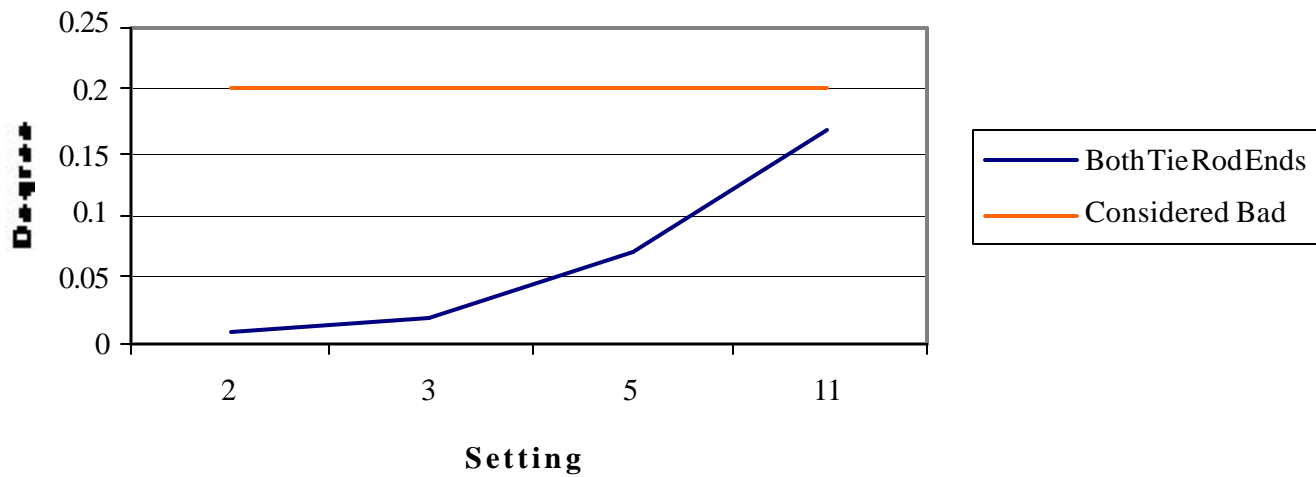


Alignment Test Degree vs. Setting One Tie Rod End





Alignment Test Degree vs. Setting Both Tie Rod Ends





Overall Conclusions / Possible Impact of Future Designs

- Human “feel” picks up lash better than a Alignment Machine
- The optimum evaluator is an engineer under 40 (male or female)
- Post test criteria of 0.5mm axial lash, .25mm radial lash should be considered for future key life tests