Manganese Cup Bowl Liners for TTX Articulated Well Cars

Track testing, Lab testing and Field Trials

1. **Goal: Evaluate life cycle costs in well cars.**
2. **Expect longer liner life and fewer CCSB adjustments.**
3. **AAR approval for Manganese Liners.**
4. **Currently TTX has about 1900 Mn Cups in service on articulated well cars on the intermediate, 125-truck positions.**

A long process starting in 1992

125-ton well cars & the DDTF

1. 125-ton well cars approved 1988. With Vertical Isolation Pads to reduce dynamic vertical load on rails to 100-ton truck levels.
2. Industry faced frequent gauge-spread derailments in curves with loaded 125-ton trucks, at UB speeds.
3. DDTF formed to address derailments, issued final report in 1992
4. Recommended non-metallic cup liners that meet lab test criteria for friction and wear (RP-261) to replace welded in vertical wear rings and horizontal liners.

A long process starting in 1992

TTX & Cup liners in 1992

1. Complied with all DDTF recommendations related to 125-ton well cars.
2. Including non-metallic cup liners in 70-ton end trucks and higher CCSB set-up heights, which were quickly reversed due to high-speed instability and leaning car issues.
3. TTX conducted Field Trials of various non-metallic cup liners.
4. Continued track tests comparing Mn steel and non-metallic liners.

Cup liner studies get interesting

1. **TTX purchased a small fleet of red well cars in the 1990's that were fitted with Mn-Steel cup liners.**
    1. **Began rush program to replace Mn-steel cups with non-metallic liners**
    2. **R&D was asked to use Truck Performance Detectors (TPD's) to find cars still equipped with Mn-steel cup liners.**
    3. **TPD's found the cars, but the Mn-steel cars had equal or better data than the equivalent TTX cars with non-metallic liners. This was completely unexpected.**

Cup liner studies stay interesting

1. **Track testing at TCCI:**
    1. **Drop-in cups simplify comparison tests of Mn-steel and non-metallic liners in well cars.**
    2. **Data from Instrumented Wheelsets does not reliably differentiate Mn-steel and non-metallic cups.**
    3. **Data is very similar and when differences in data do occur it is not always in favor of the non-metallic liner.**
    4. **Track tests agreed with the TPD's on liner comparisons from the red cars.**

Questions arise

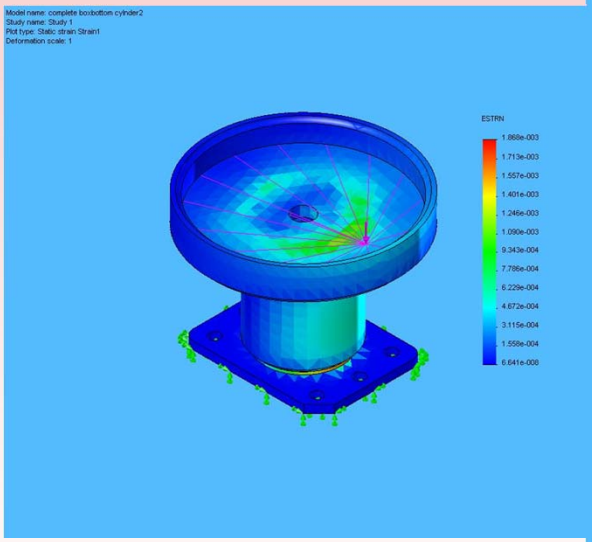
1. Conventional wisdom held that non-metallic liners had a large reduction in friction compared to metal, at least 50% less: 0.2 vs. 0.45μ
2. Yet none of the tests found a corresponding large change in truck performance.
3. Either the friction level is not so different or it is in a range that simply does not show up in wheel forces.
4. Cup liners act more alike despite materials used, and differ from welded-in ring and horizontal liners.

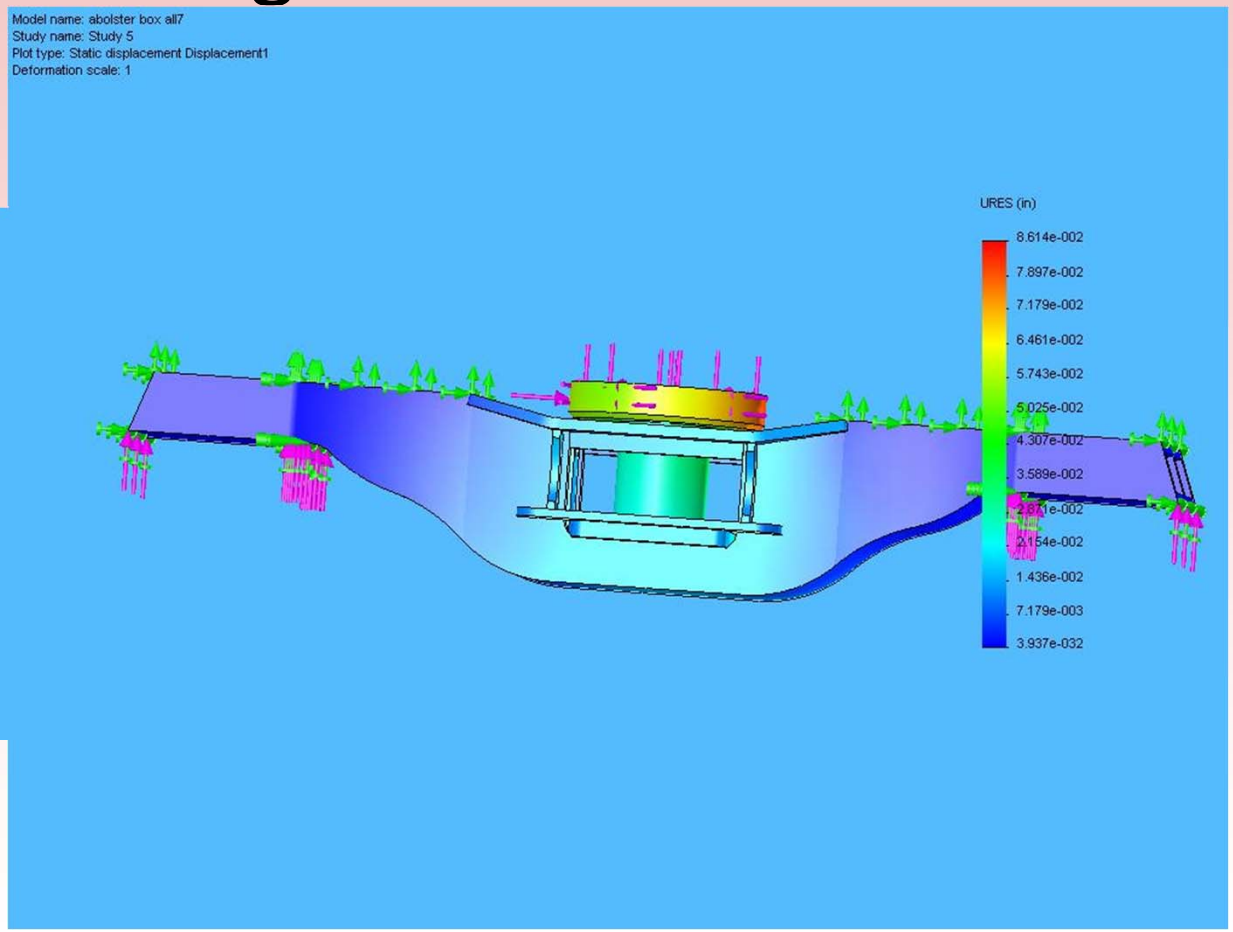
Answers & a path forward

1. Decided to measure the torque on a 125-ton bolster directly to compare liner materials.
2. Include torque on bolster from side bearing pedestals.
3. Track test at WRM loop at TTCI.
4. Three cup liner configurations to be tested, non-metallic, Mn-steel and Mn-steel with lubrication (standard RR lube disk)
5. As with DDTF, full load and UB speed is worst case.

Torque Measuring Bolster

Design & FEA

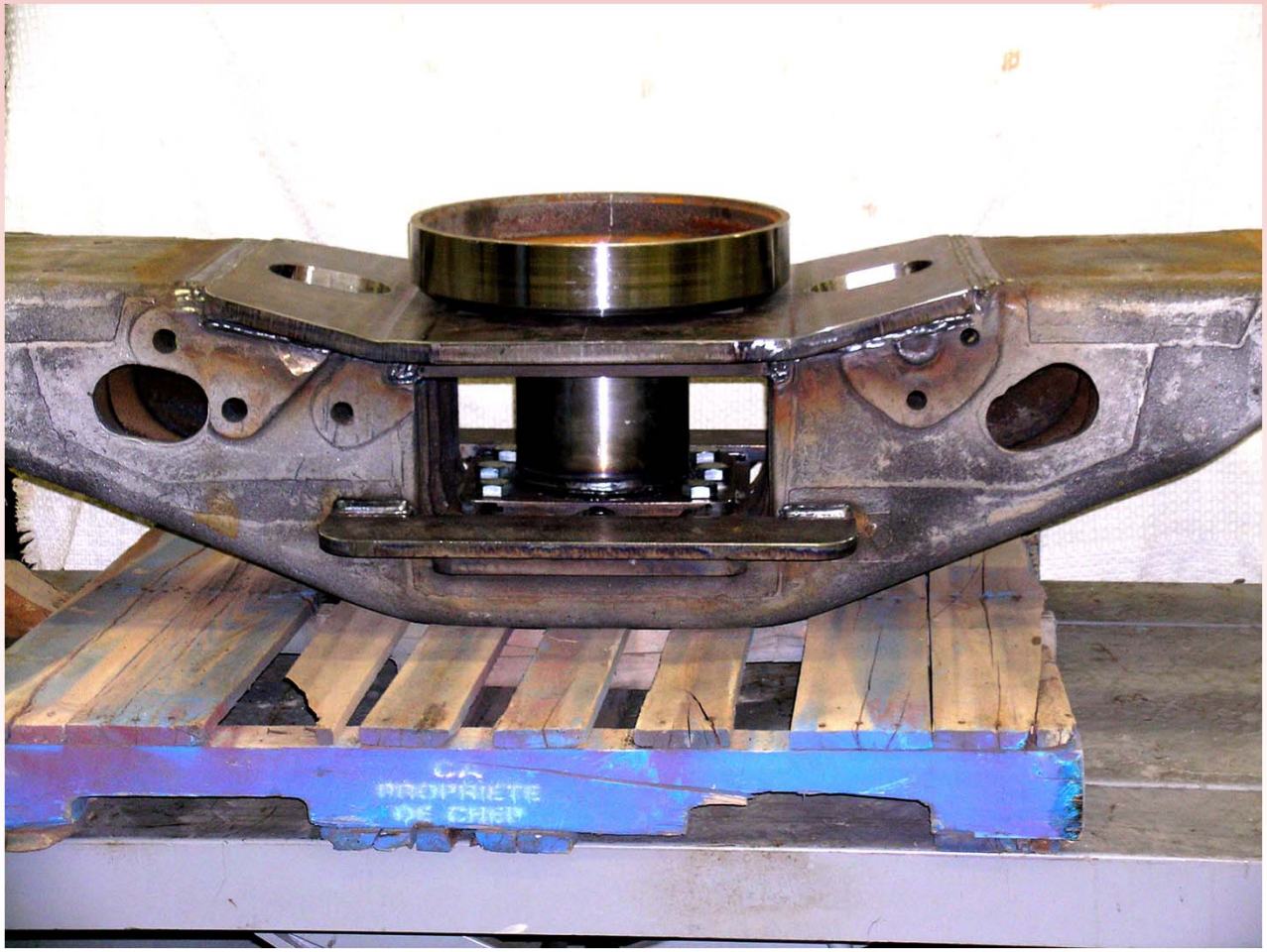




Torque Measuring Bolster

Construction

Torque Measuring Bolster
Construction

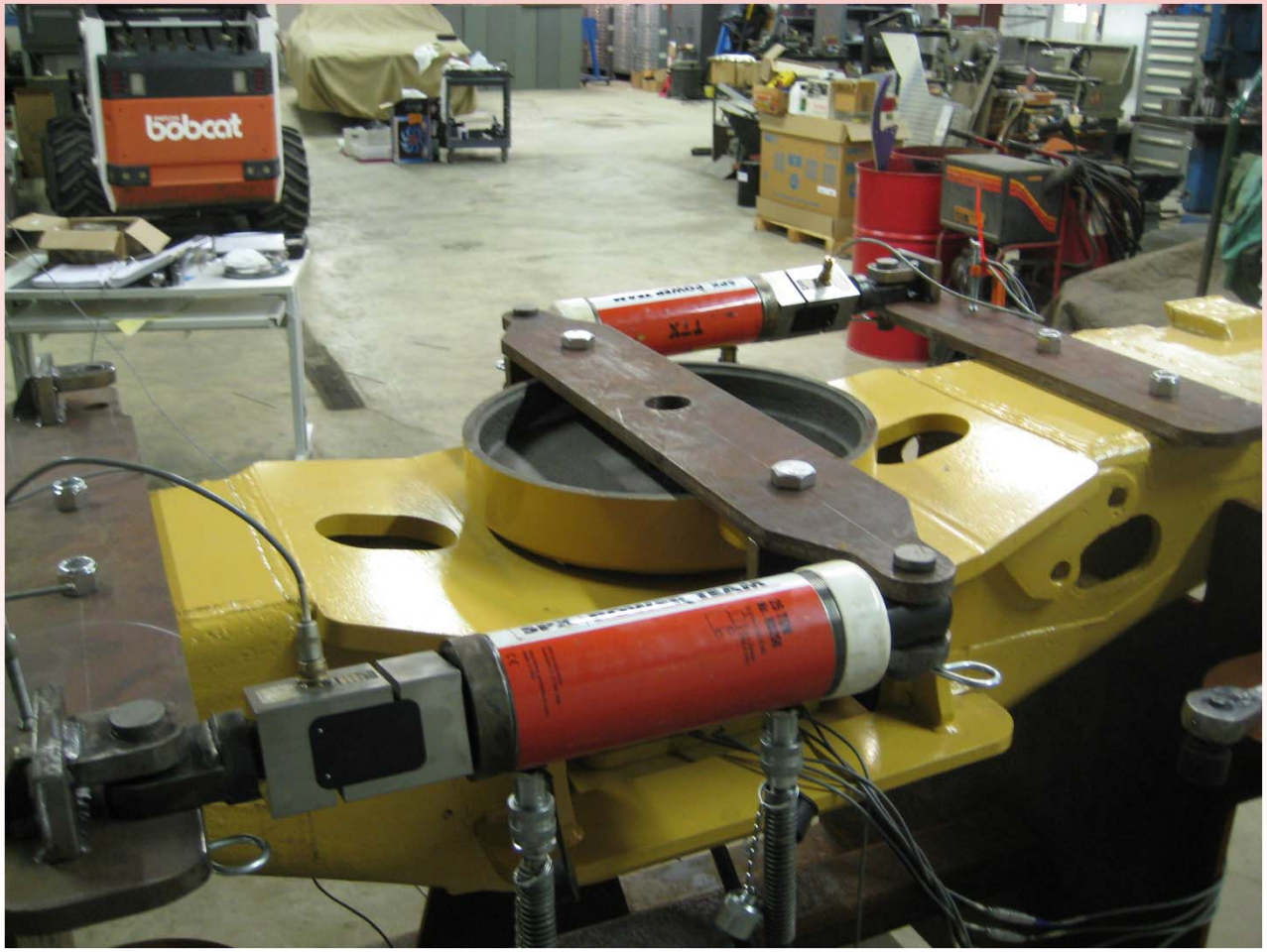


Torque Measuring Bolster
Construction

Torque Measuring Bolster

Side Bearing pedestals

Torque Measuring Bolster
Calibration

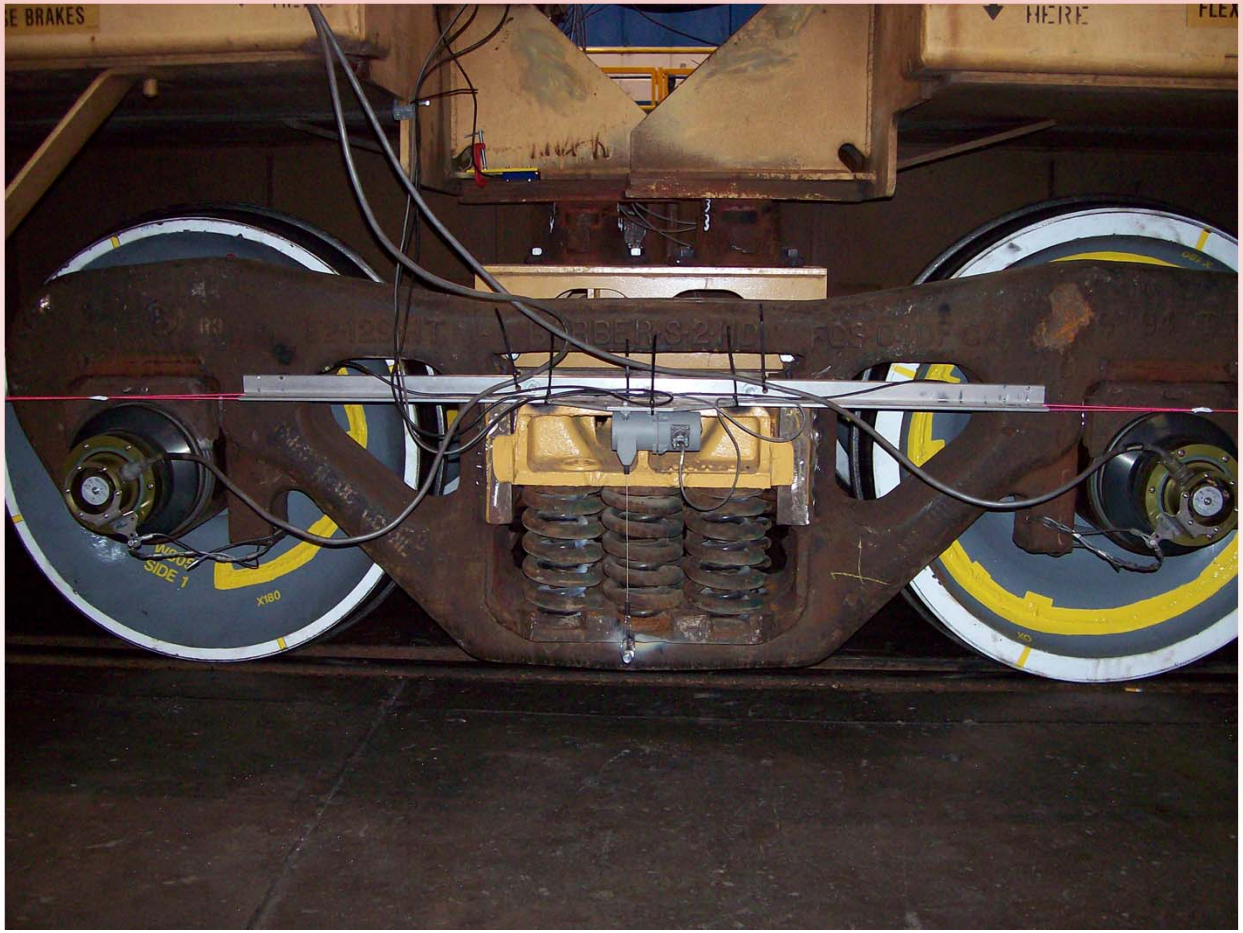


Torque Measuring Bolster
Calibration

- Calibration by ME interns Corine & Erica
- Sr. Design Project
- Presented at SWE

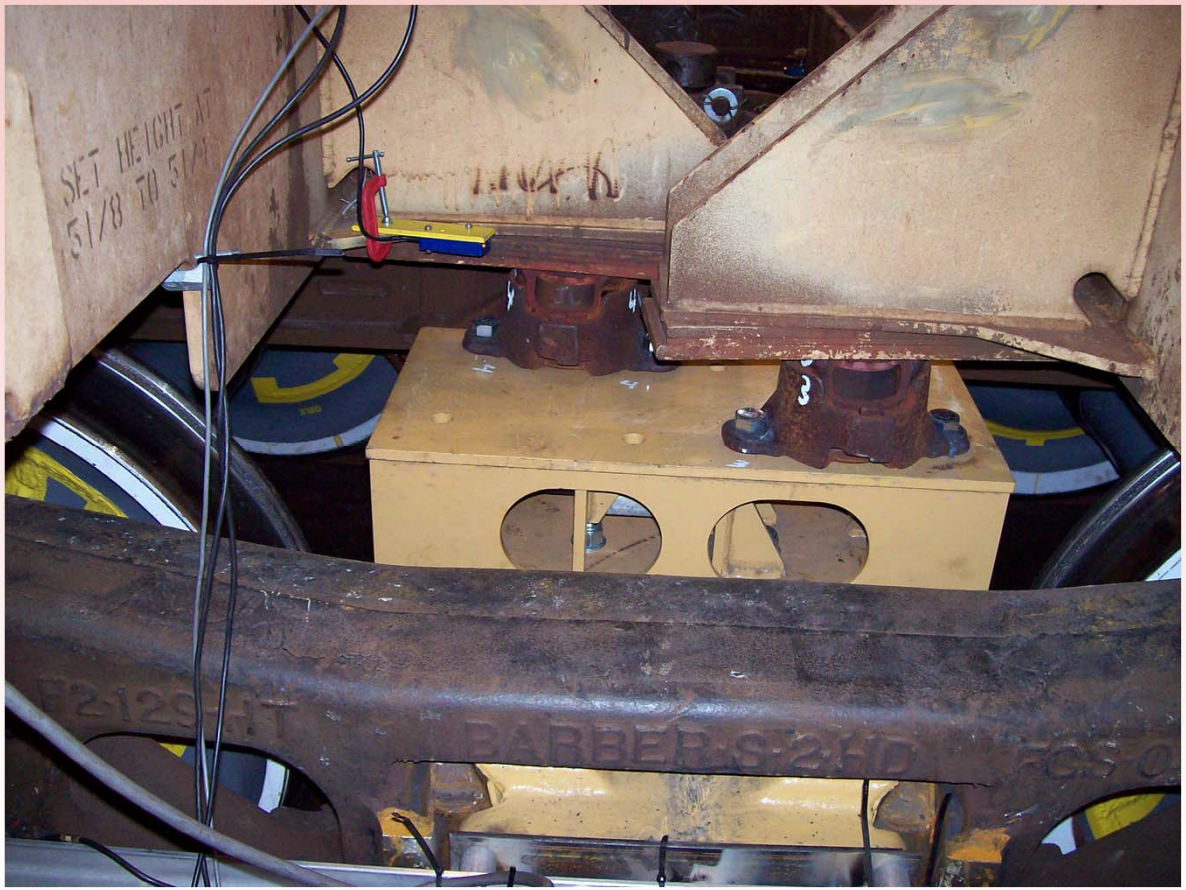
Torque Measuring Bolster

Track Testing



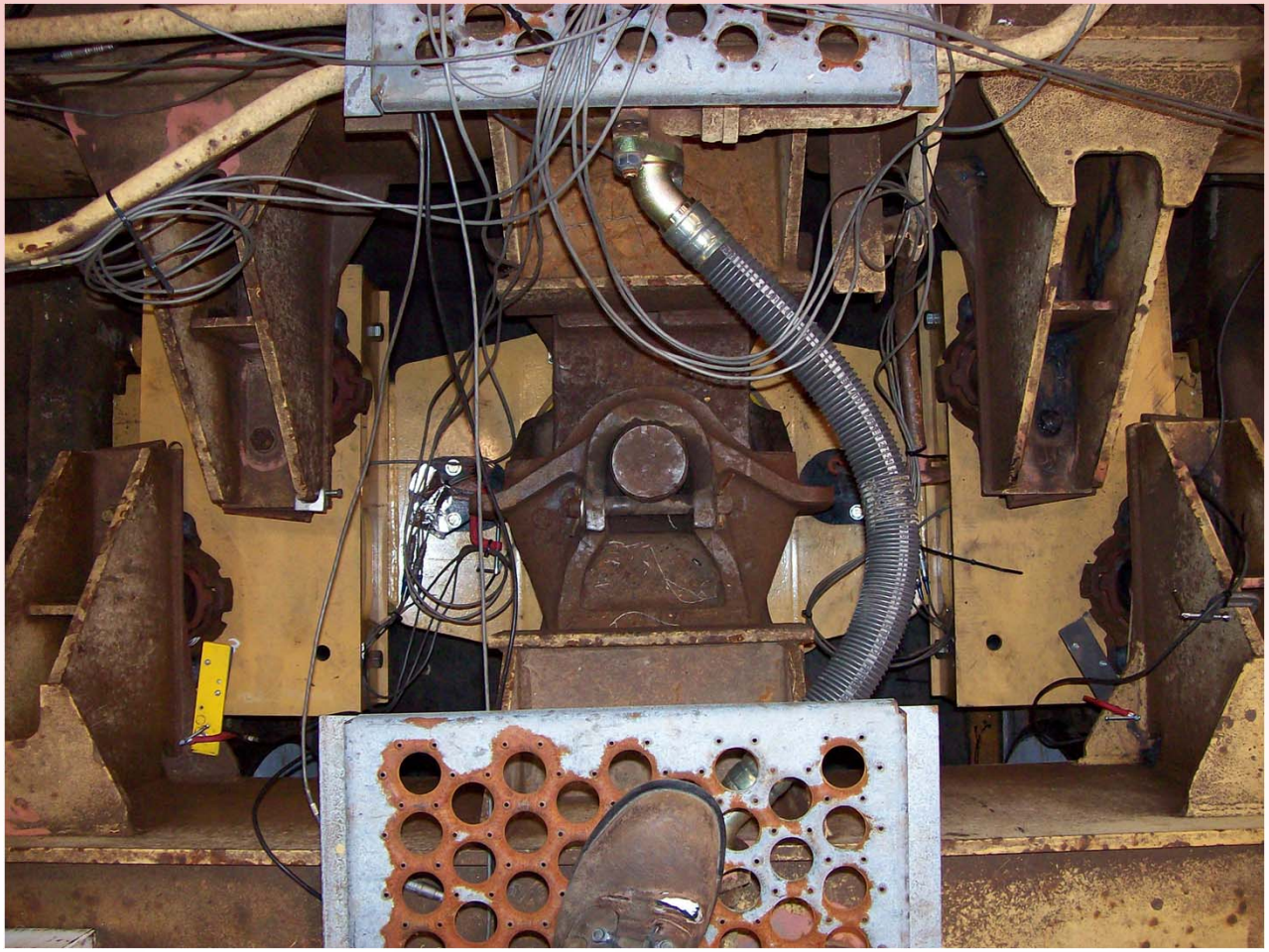
Torque Measuring Bolster

Track Testing, CCSB Pedestal



Torque Measuring Bolster

Track Testing, Top View

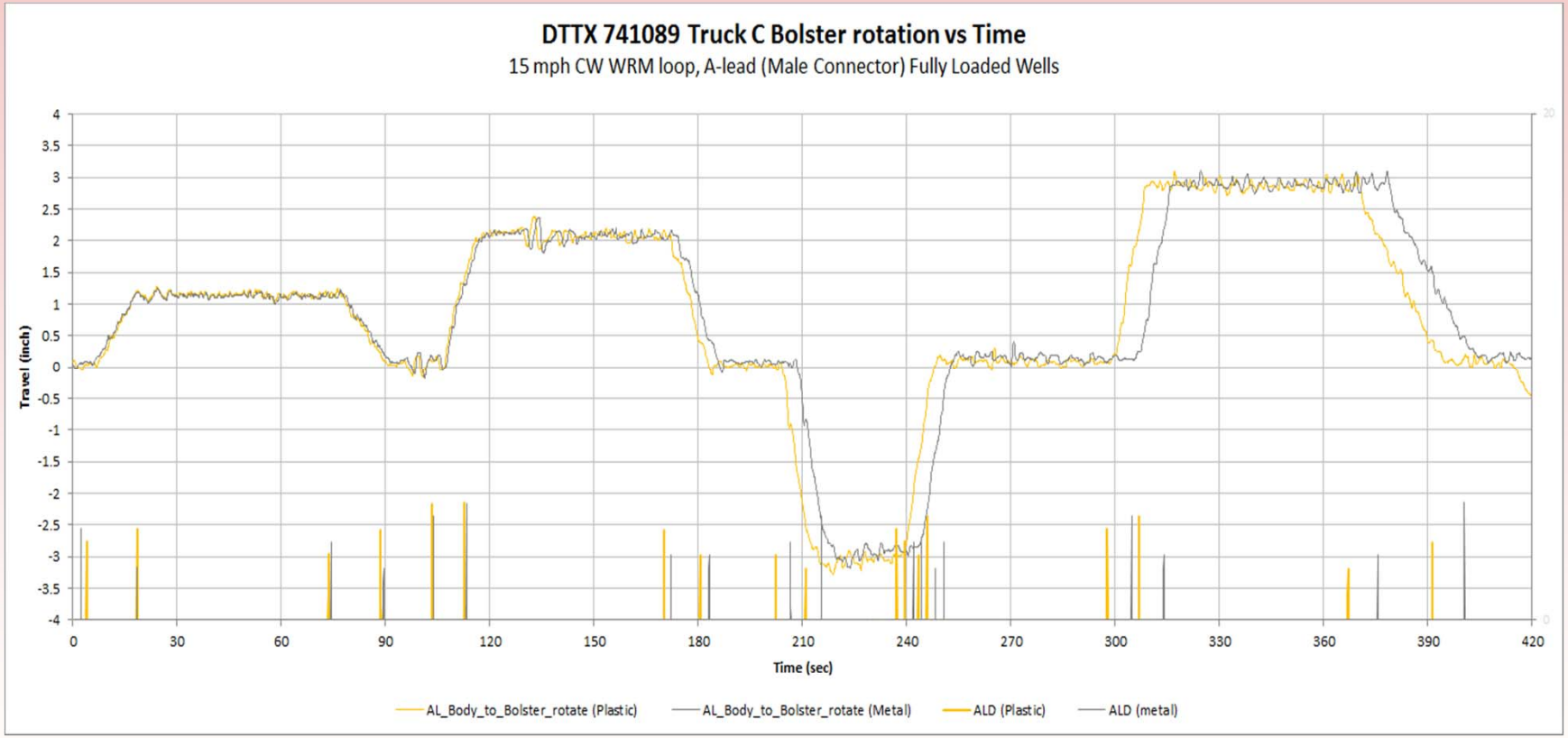


Torque Measuring Bolster

Track Testing, Full Load

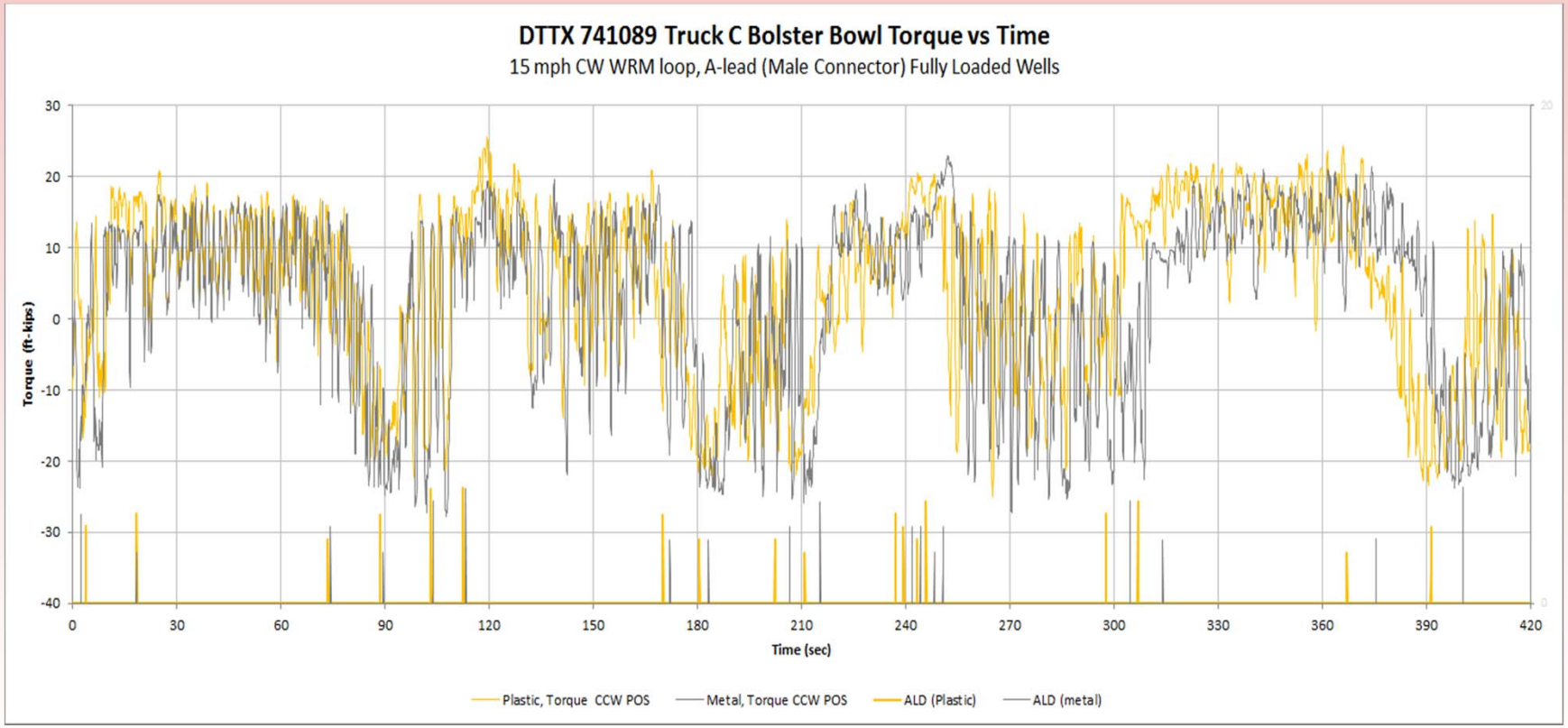
Torque Measuring Bolster

Test results, Bolster Rotation, UB speed

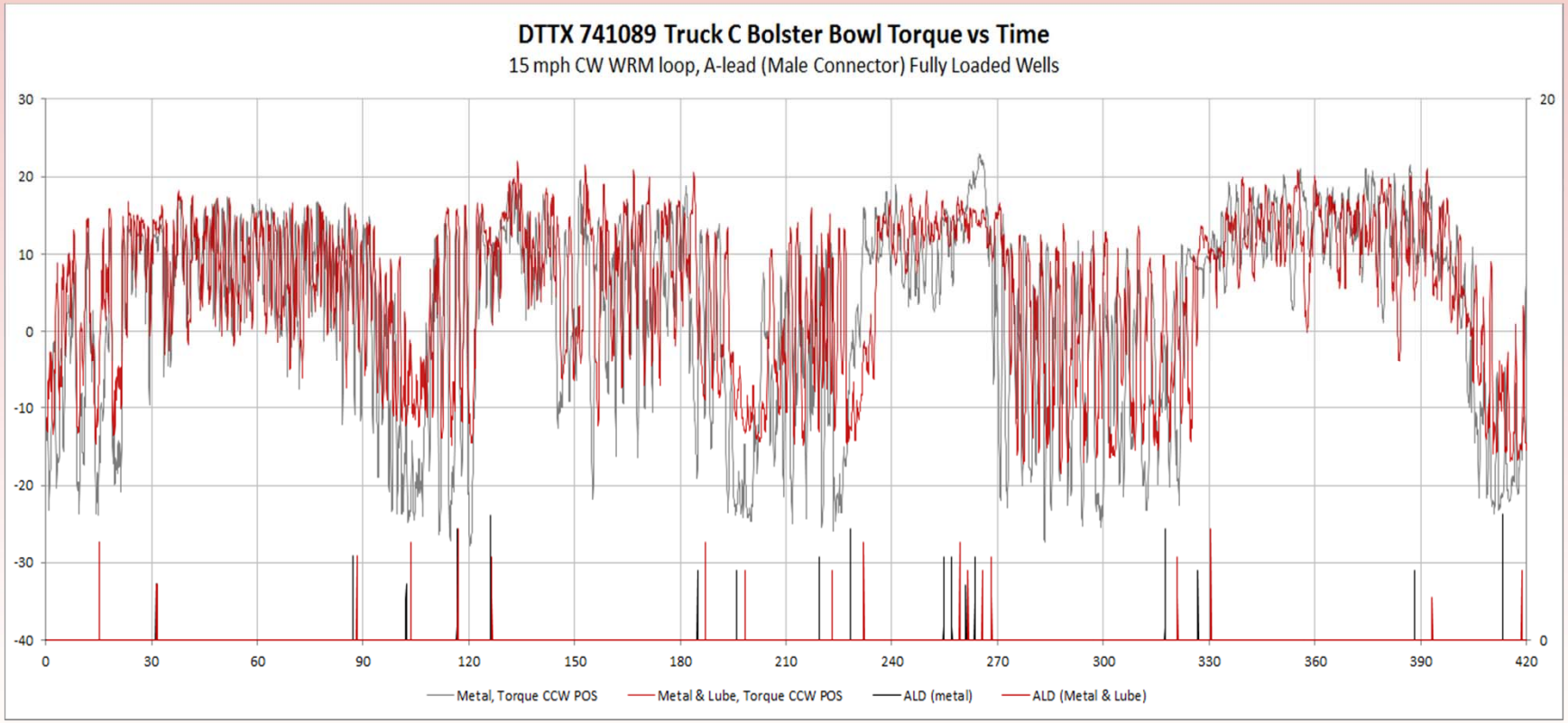


Torque Measuring Bolster

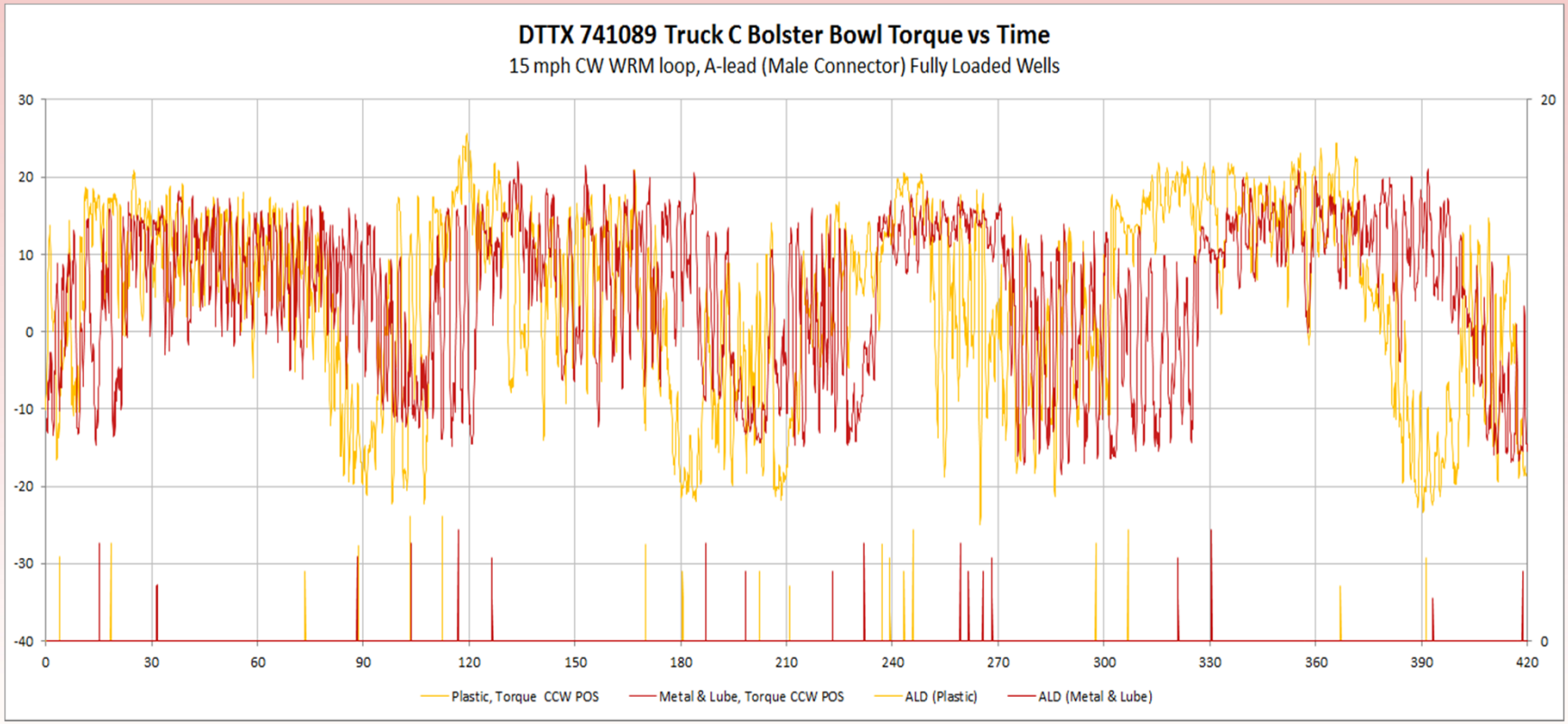
Test results, Torque on Bowl, UB speed



Torque Measuring Bolster
with Lube, Torque on Bowl, UB speed

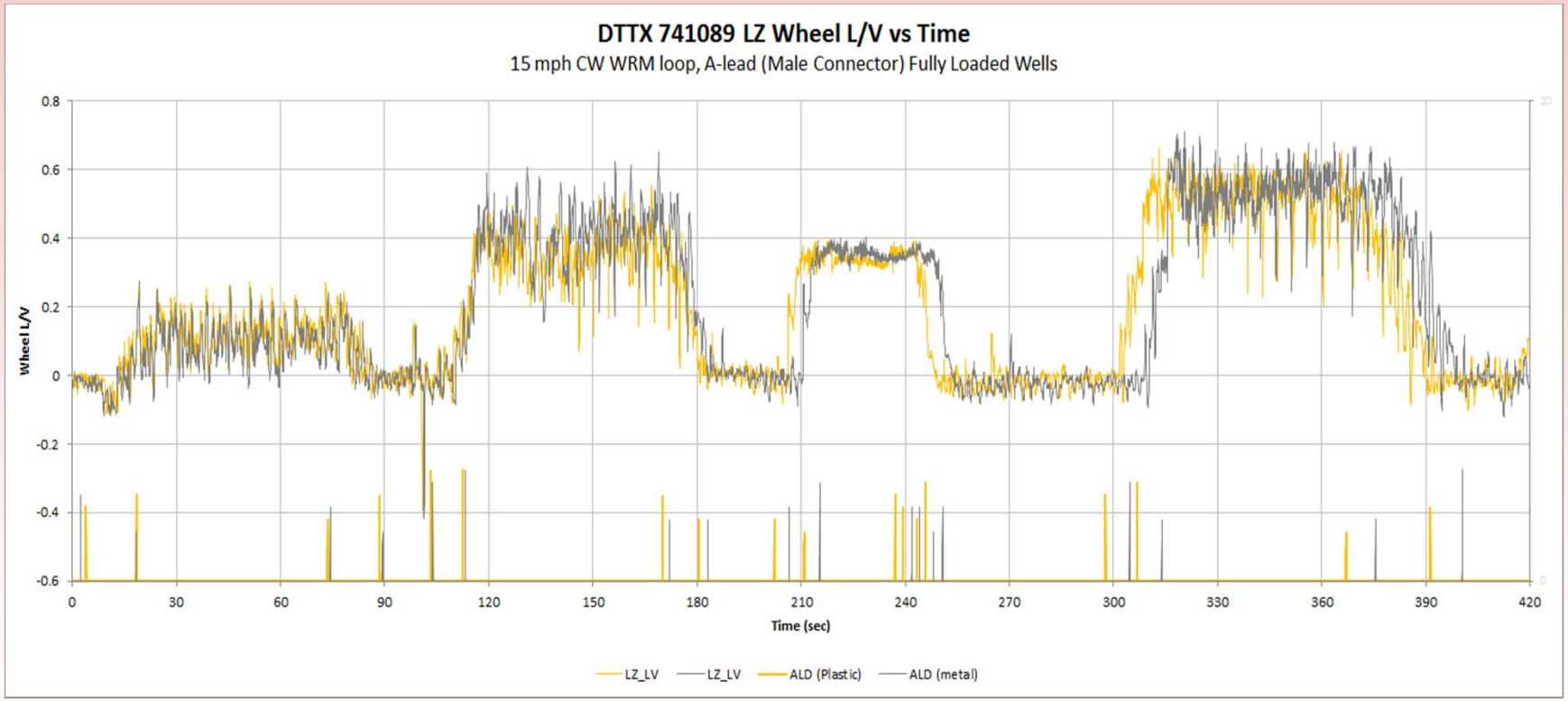


Torque Measuring Bolster
with Lube, Torque on Bowl, UB speed

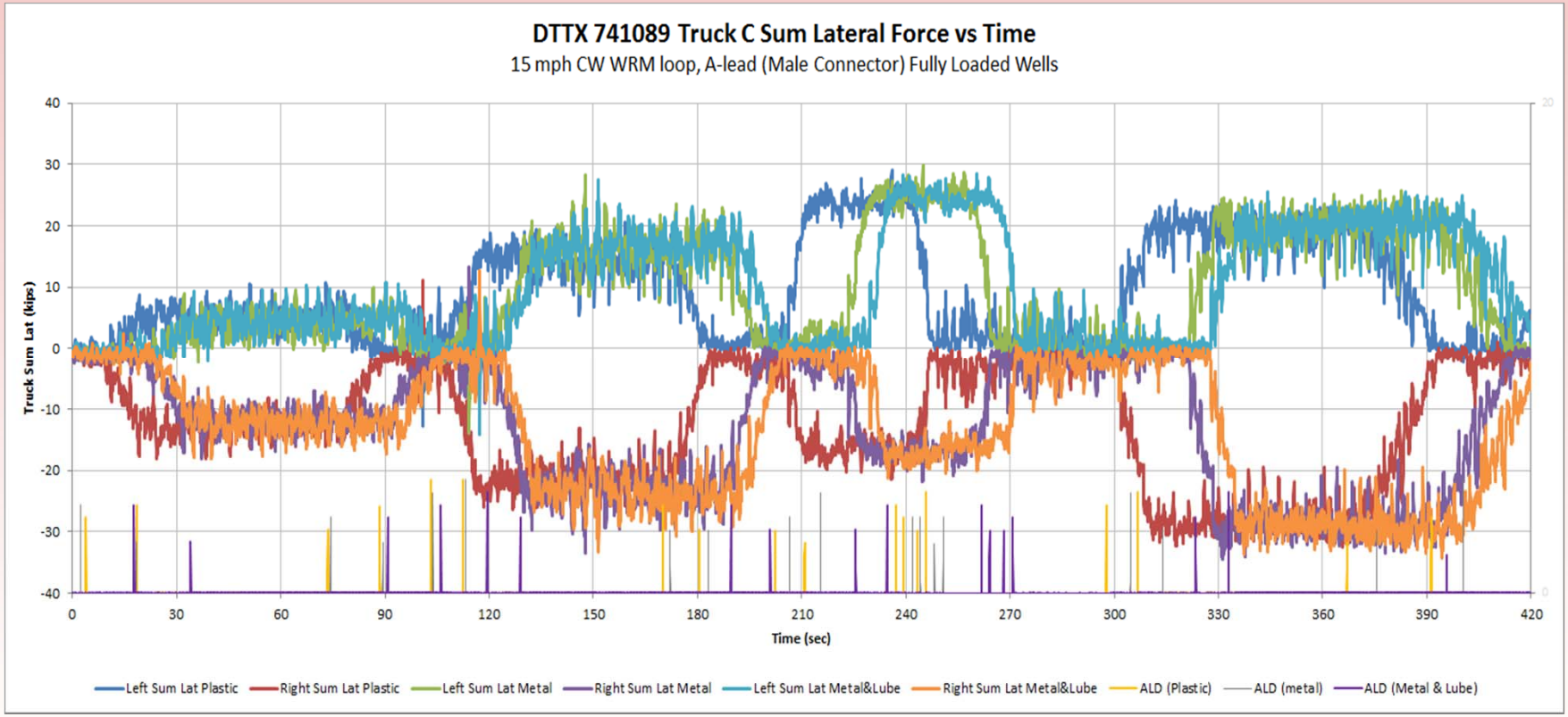


Torque Measuring Bolster

LZ Wheel L/V, UB speed

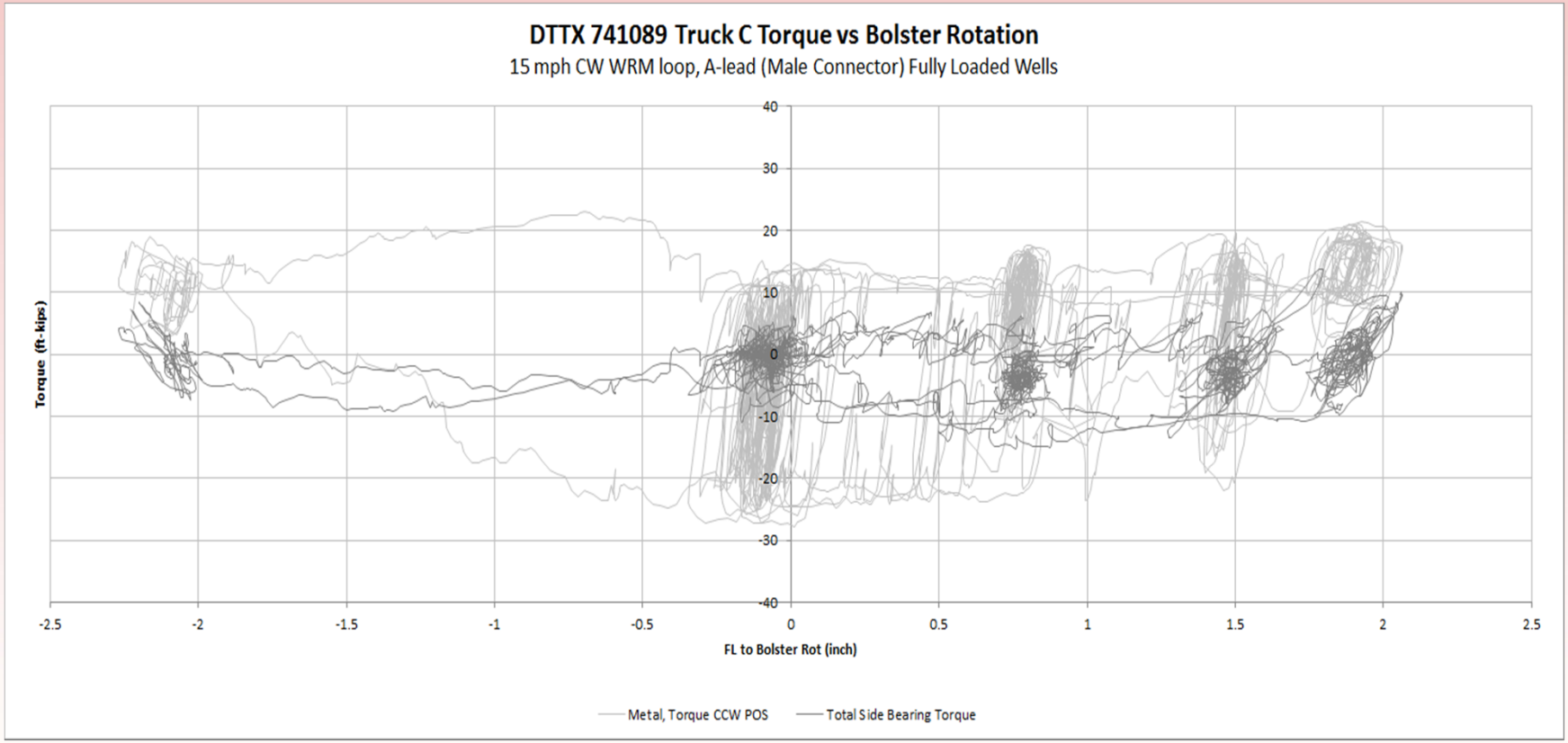


Torque Measuring Bolster
Gauge-Spread Force, UB speed



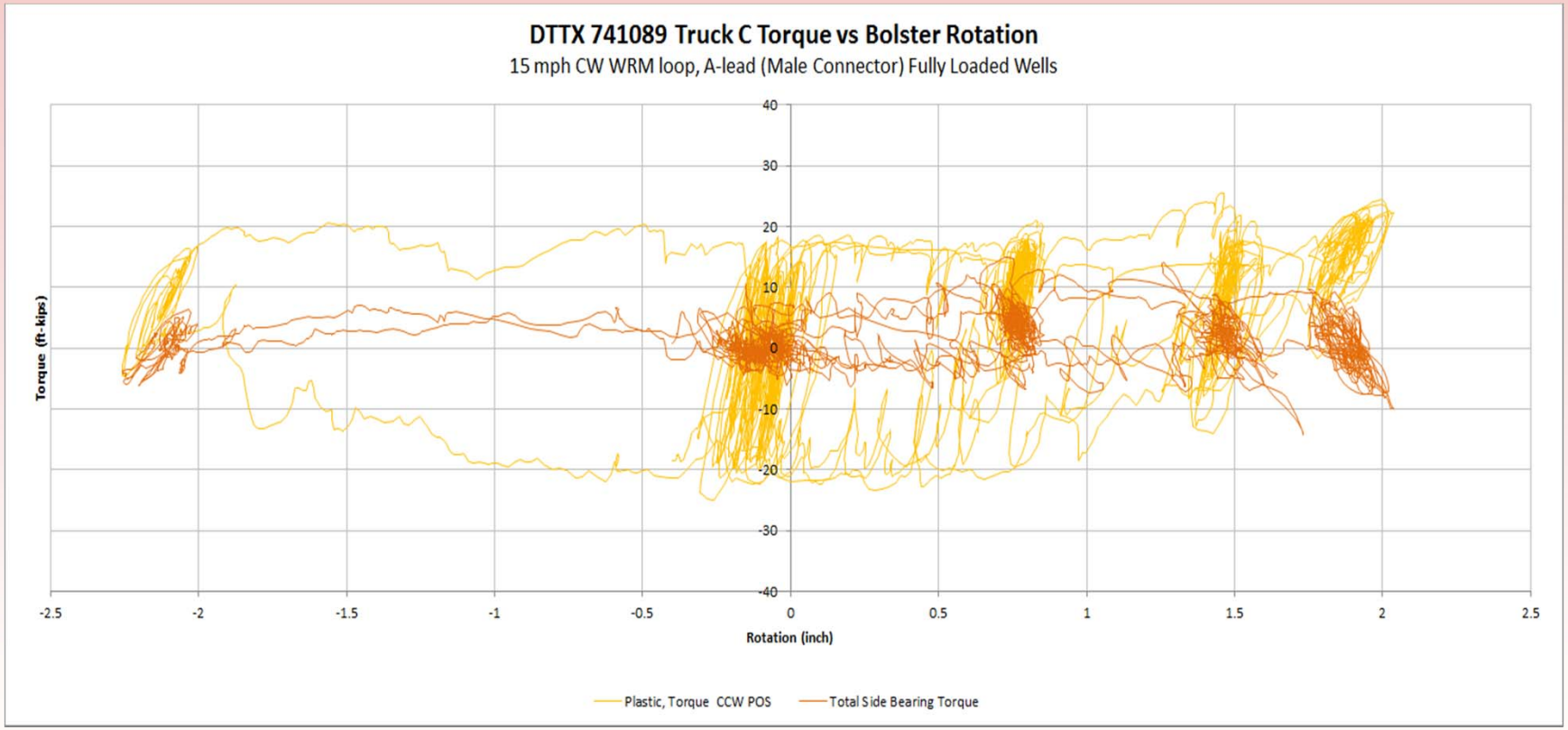
Torque Measuring Bolster

Metal Torque vs. Displacement, UB speed



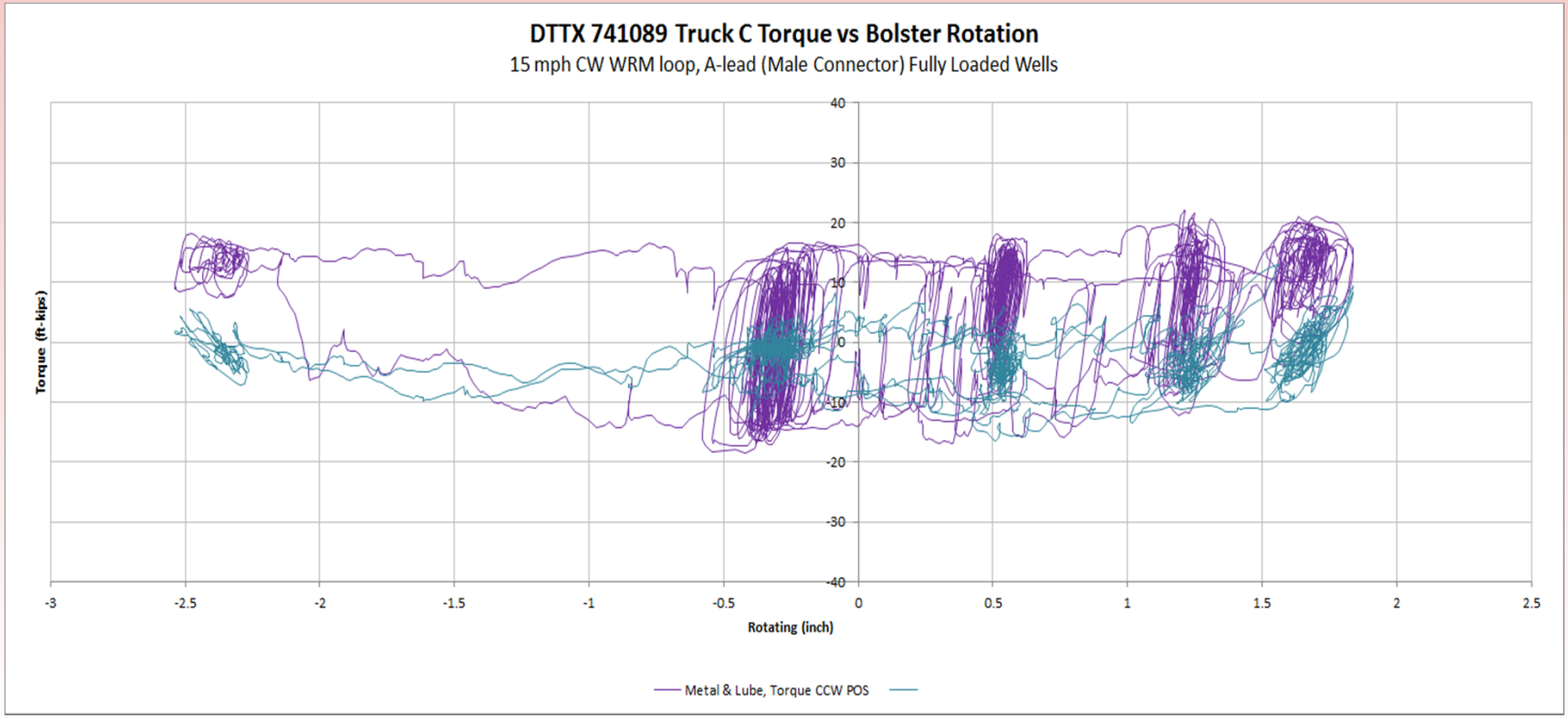
Torque Measuring Bolster

Non-Metal Torque vs. Displacement, UB speed



Torque Measuring Bolster

Lubed Metal Torque vs. Displacement, UB speed



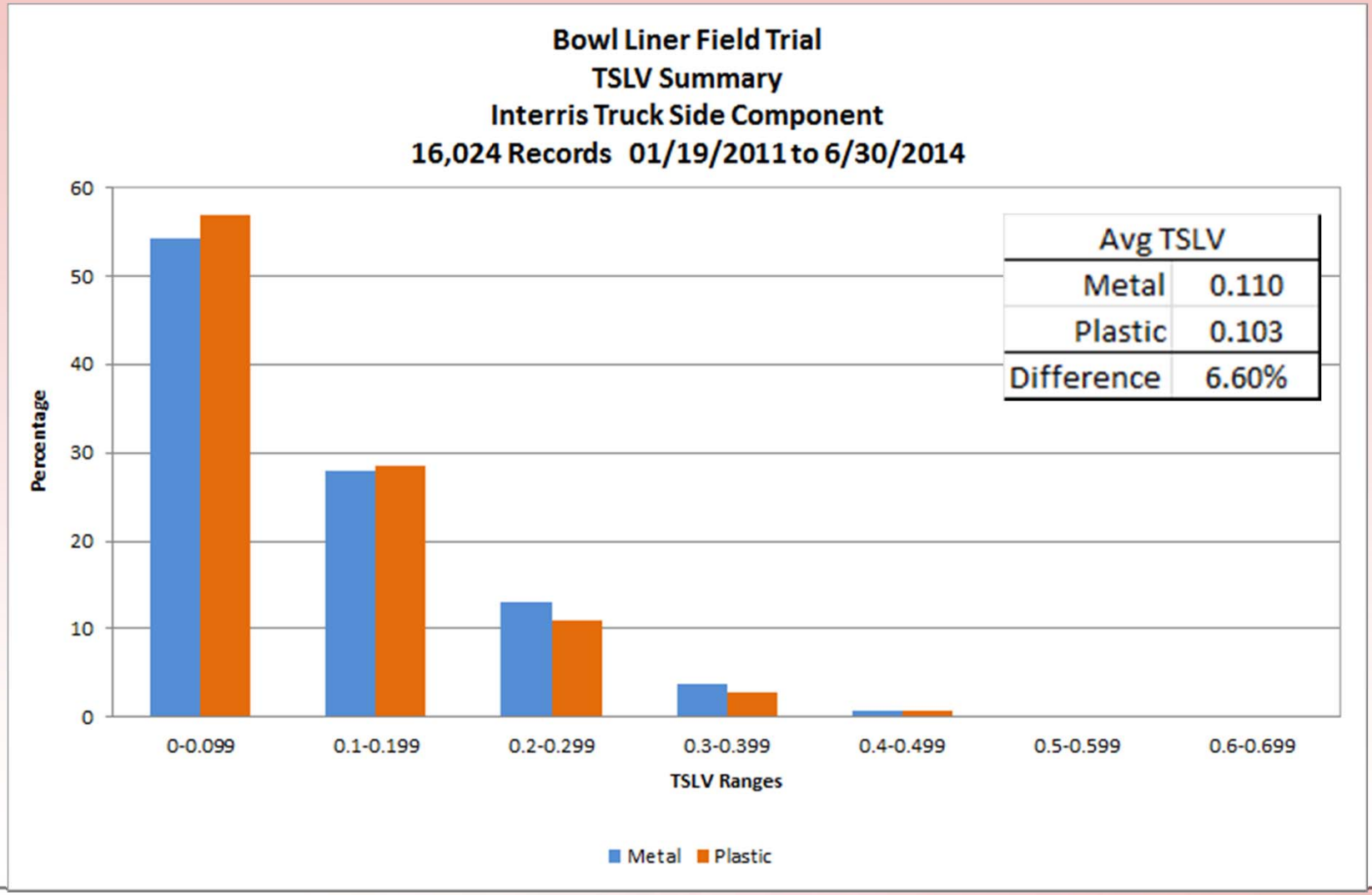
Results from track tests

1. The two liner materials have similar torque values on bolster and very similar Wheel/Rail forces.
2. TTX is now confident in proceeding with Mn-Steel Cup liners with the AAR.
3. Mn-Steel cups tested in 2008, met AAR RP-261 requirements (143 in-kip vs. 300 in-kip max).
4. Started AAR Field Trial in 2009 with 40 cups.

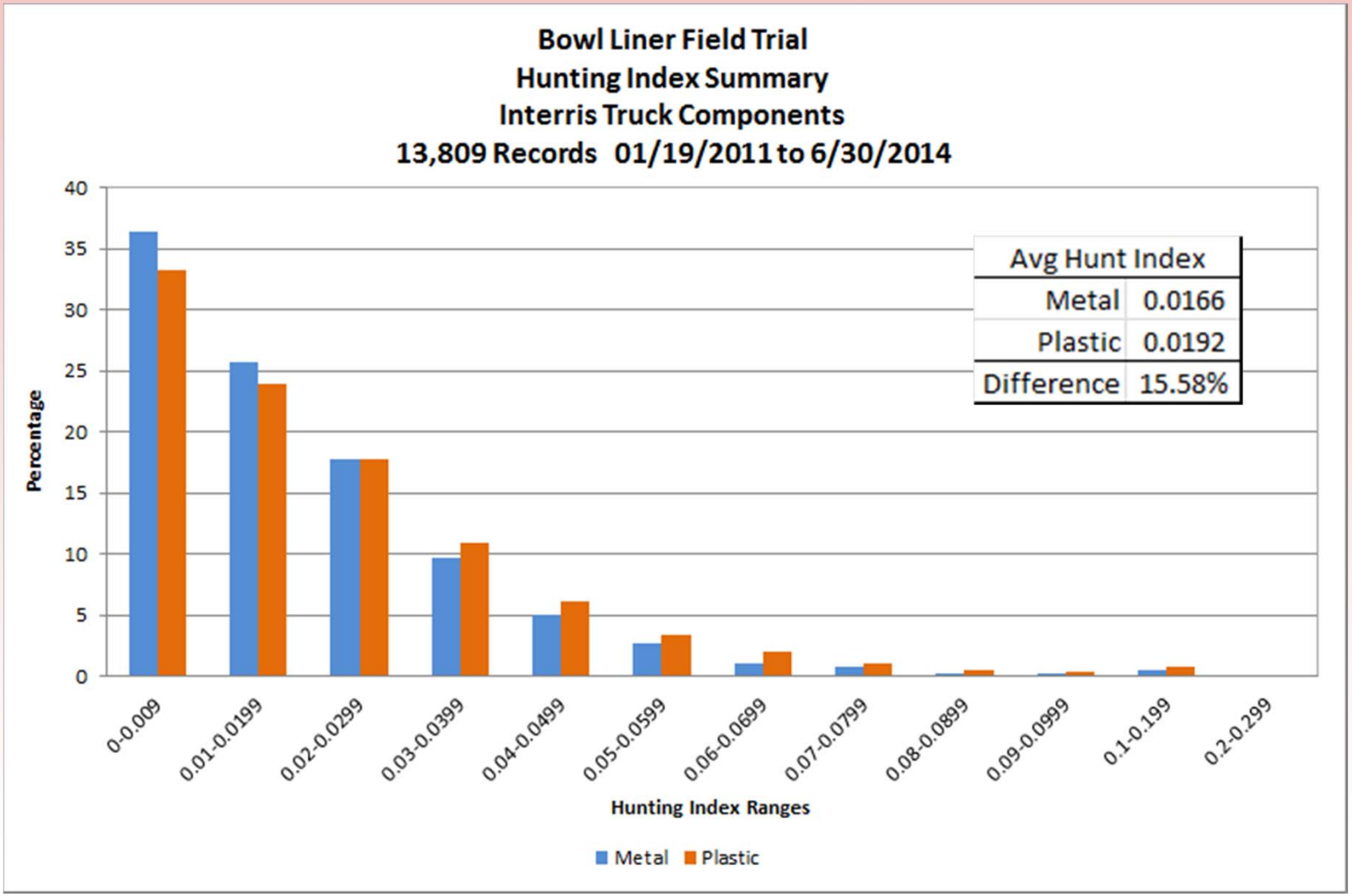
AAR Field Trial

1. Started in 2009 with 40 cups
    1. Half of the trucks in the articulated well cars were equipped with Mn-Steel cups and half with non-metallic cups for comparison over TPD and THD detectors.
    2. Used Truck Side L/V (TSLV) from TPD's as this measure increases rapidly with resistance to bolster rotation.
    3. Used Hunting Index (HI) from THD's.

AAR Field Trial-TPD



AAR Field Trial-THD



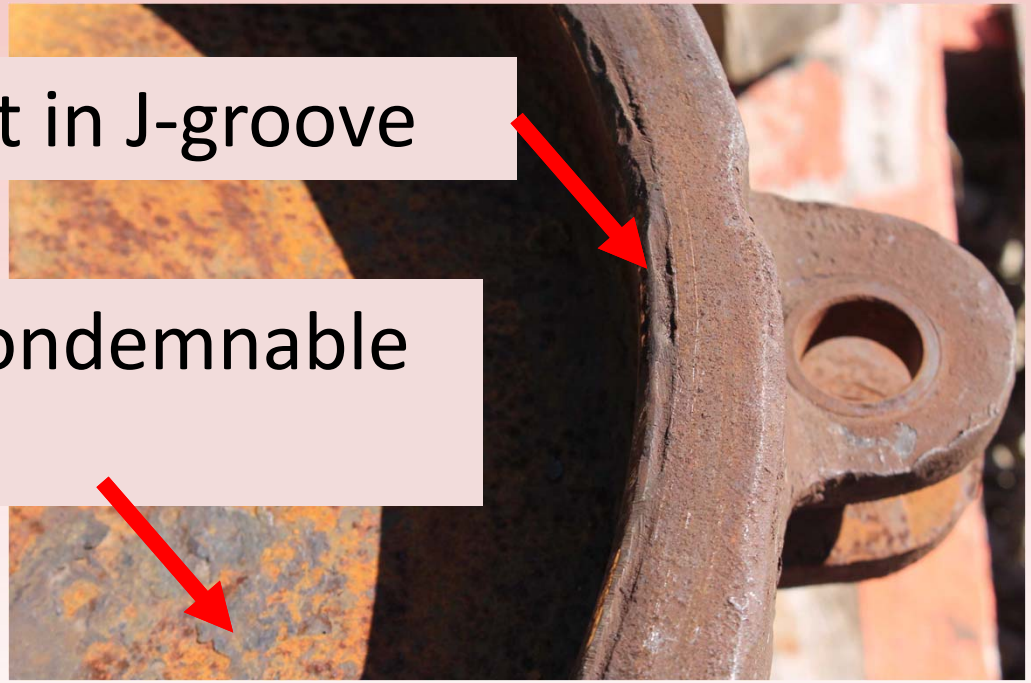
AAR Field Trial wear results

200k miles			
	Avg Thickness Loss in %		
Car	Metal		Plastic
750322	8.4		10.5
744000	10.2		28.6
759108	13		14.3
748640	10.1		15
765001	8.8		5.3
Average:	10.1		14.74
Difference:			-46%

AAR Field Trial Results

- Based on success of 2009 trial of 40 liners, TTX received approval to expand trial to 2000 cups in 2010.
- Uncovered an issue with cup liners and weld metal left in bolster J-groove (1992 and earlier bolsters).
- Cups are damaged by lack of clearance.

Issue with weld metal left in Bolster bowl J-groove



- Both Bowl Liner types use J-groove space for turn radius to lip on cup.

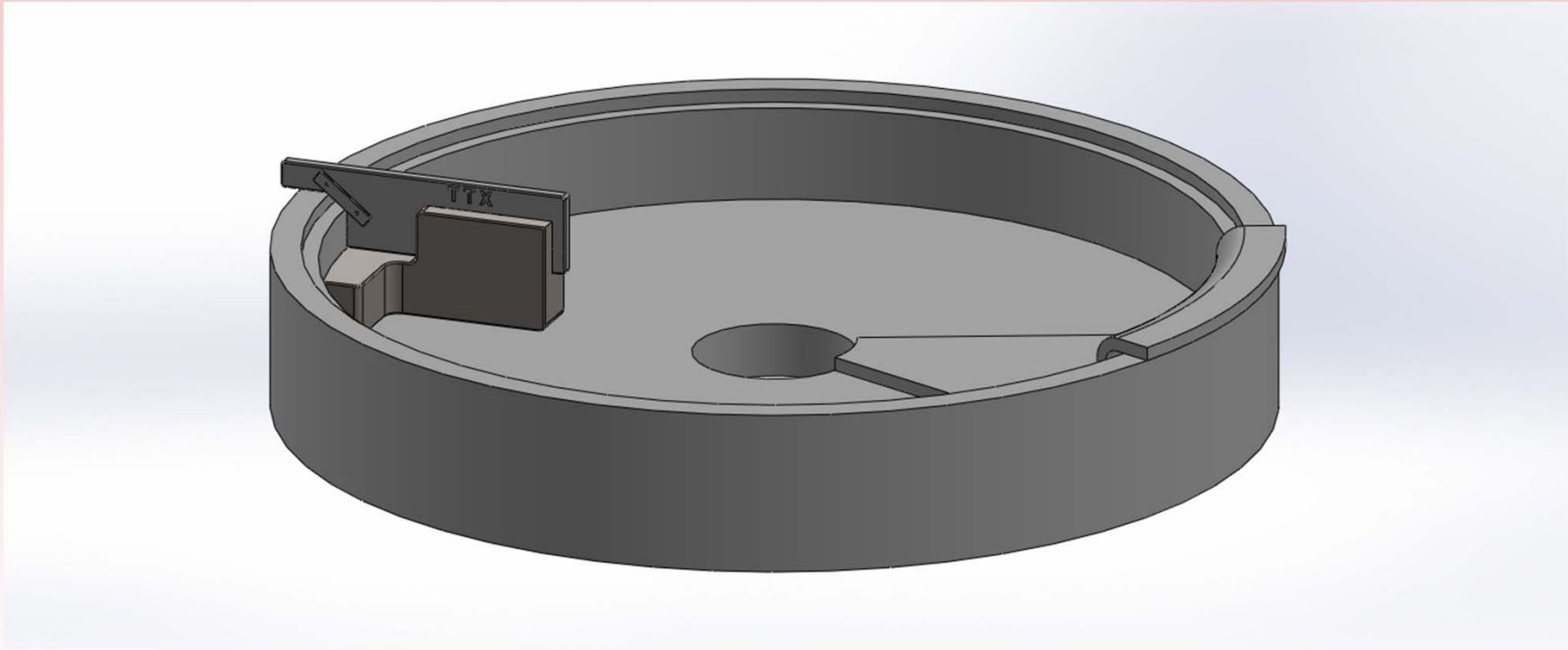
Weld metal left in bowl J-groove

- Issue with non metallic liners

Weld metal left in bowl J-groove

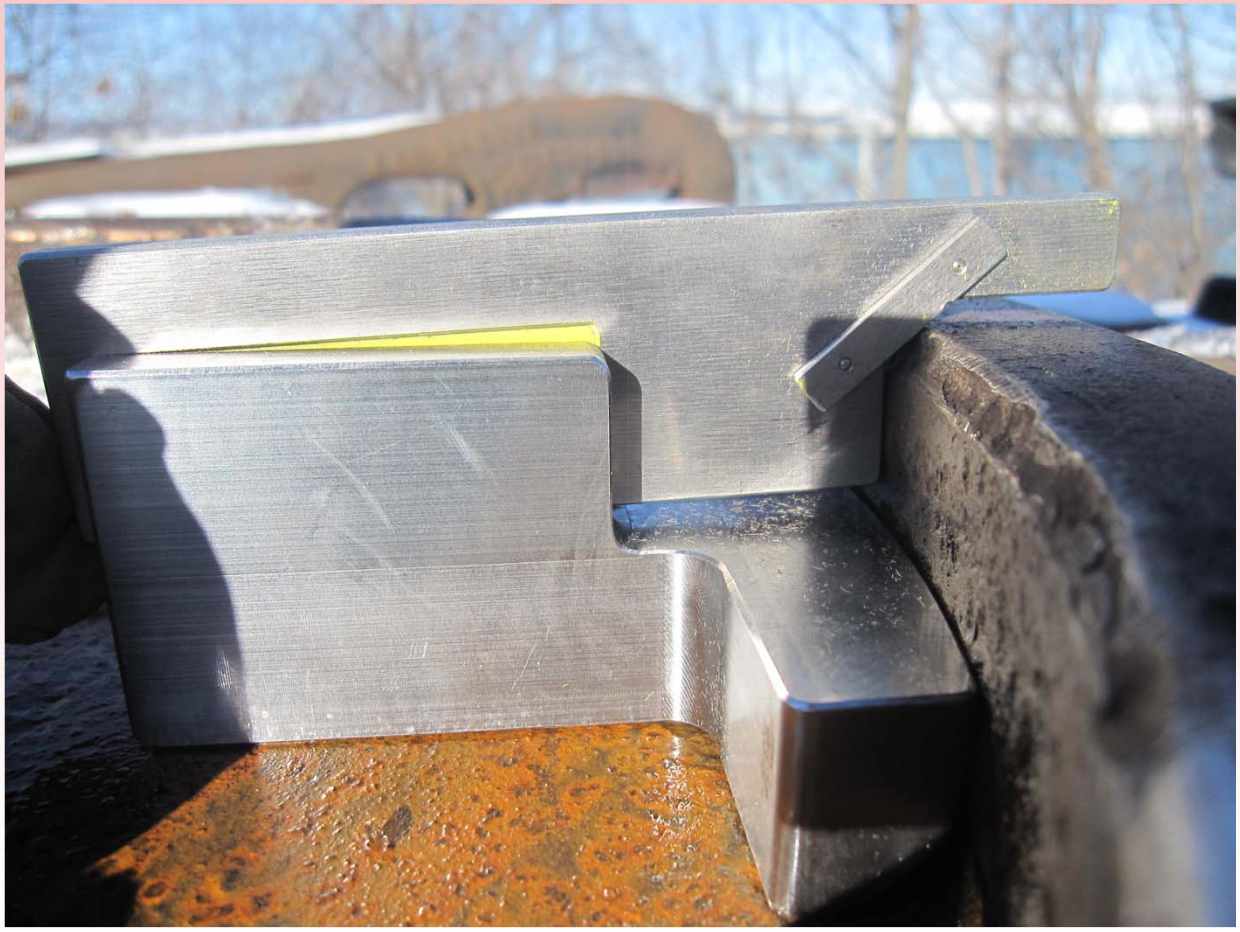
- Issue with non metallic liners

Gauge for J-groove weld removal



Gauge for J-groove weld removal-pass

Gauge for J-groove weld removal-fail



Conclusions

1. Mn-steel and non-metallic cup liners have similar torque values on bolster and similar wheel/rail forces in curves.
2. Slight advantage in curving for non-metallic and a slight advantage to resist hunting for Mn-Steel cups.
3. Expect Mn-Steel cups to have longer life and less thickness loss, perhaps fewer CCSB adjustments.