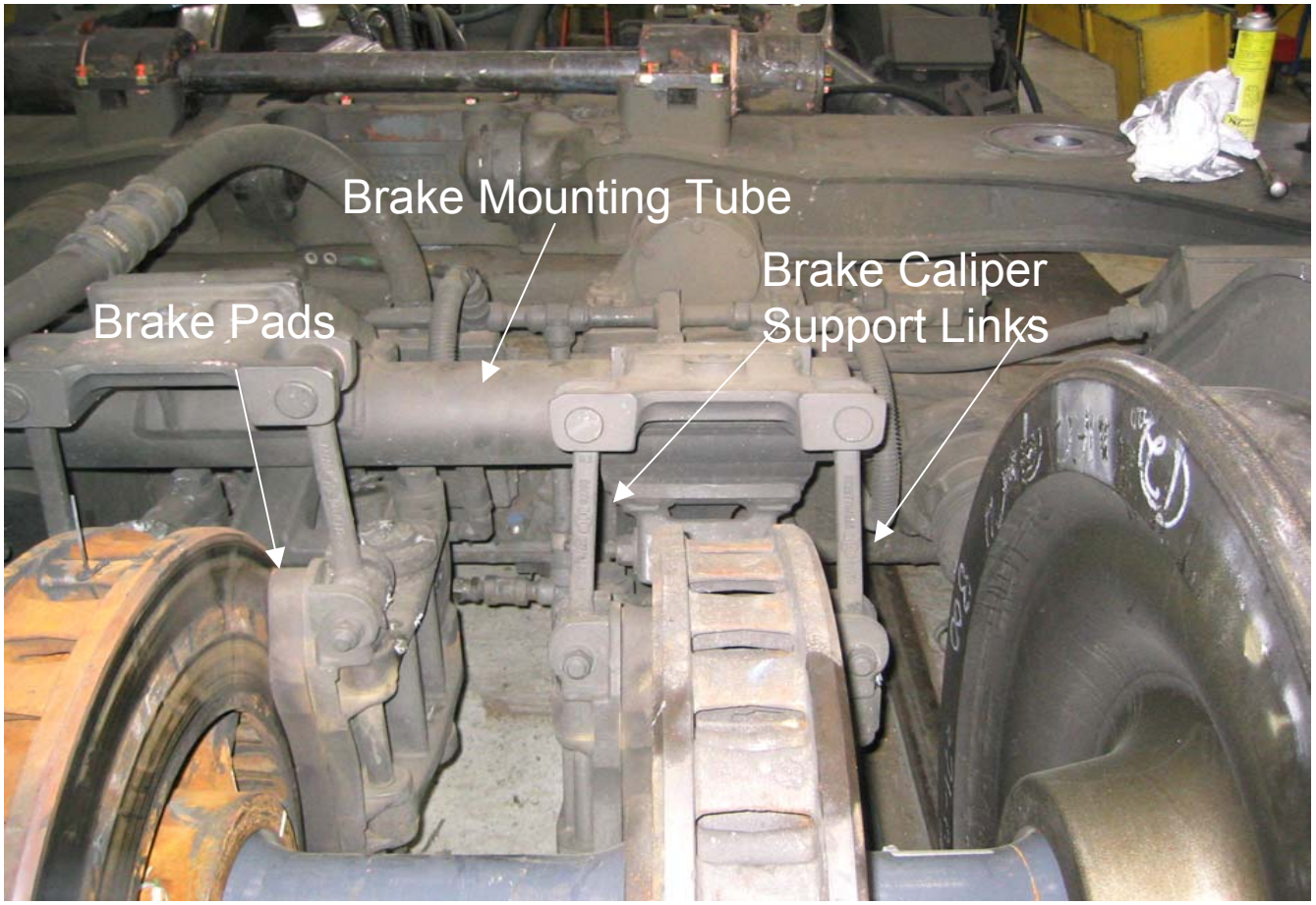
Appendix K: Brake Support Links

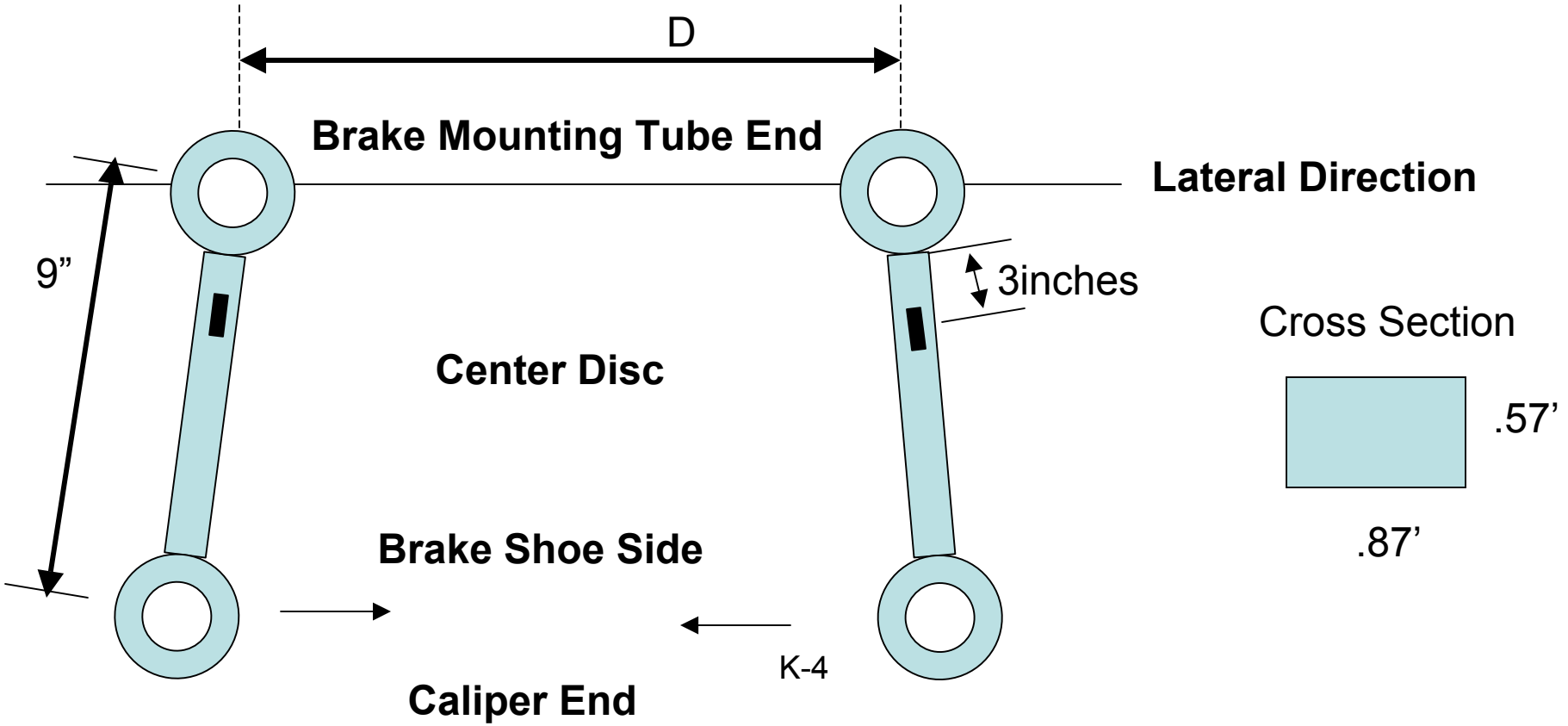
Link Descriptions

Brake Caliper Support Links

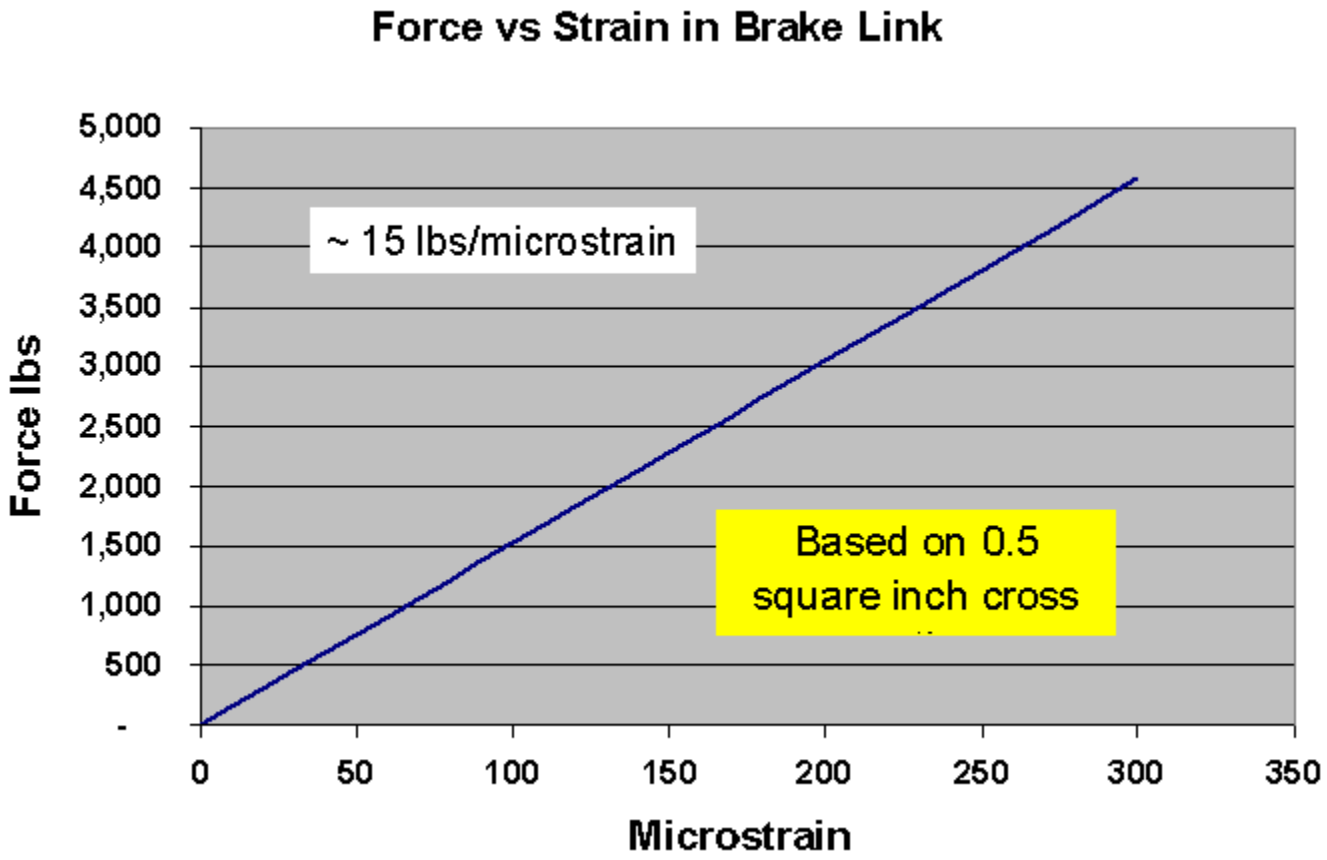


Gage Location

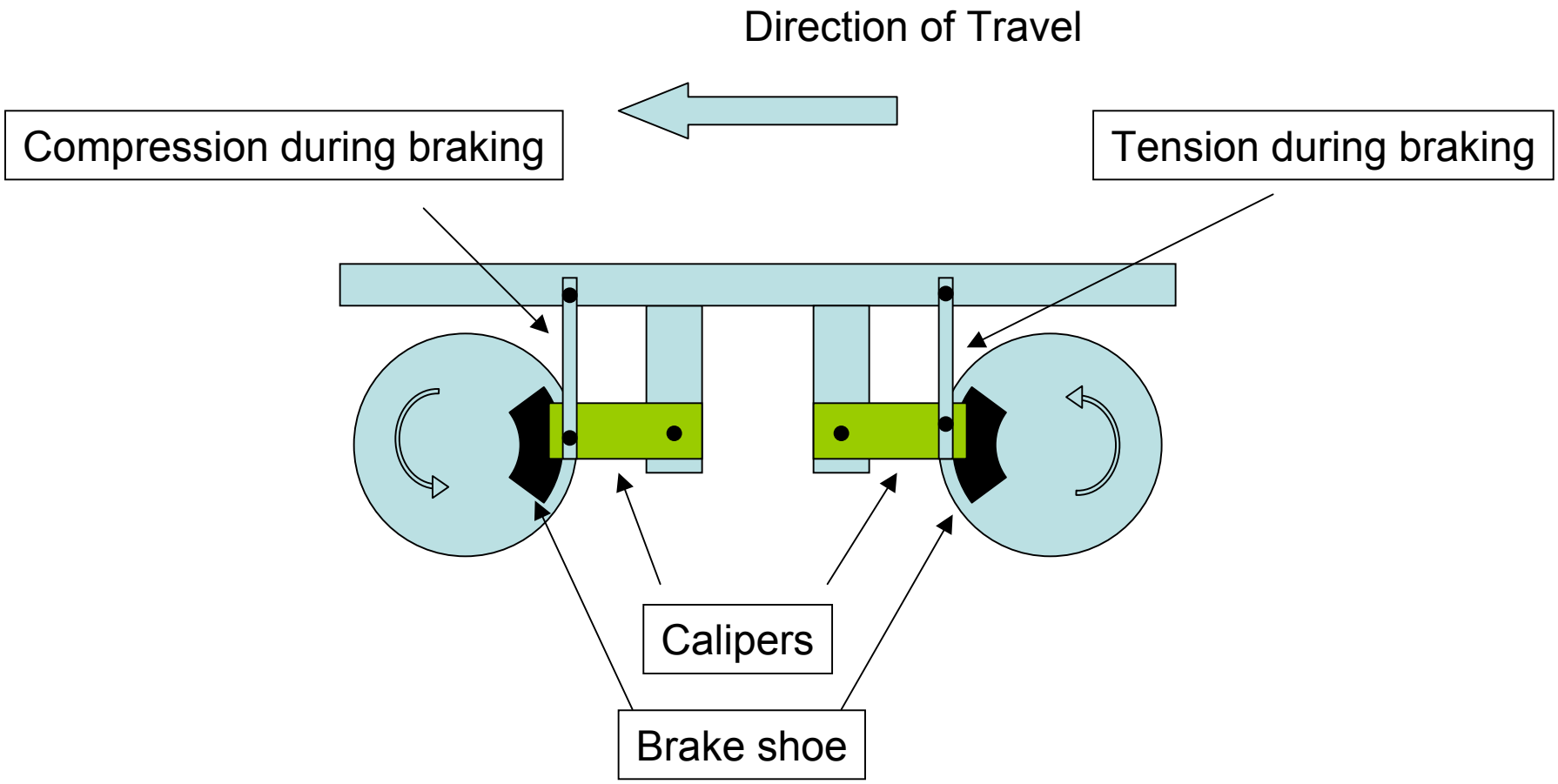
- 3 Inches Down From Top
- Face Inside – Towards Center of Truck



Force vs Strain in Brake Link



Expected Behavior



Major Assumption

- The Strain Measured By The Single Strain On The Link Is A Good Indication Of Strain In Link
- Should Be A Good Assumption Since The Link Is Pinned At Both Ends

Examples of Link Behavior

Data Selection

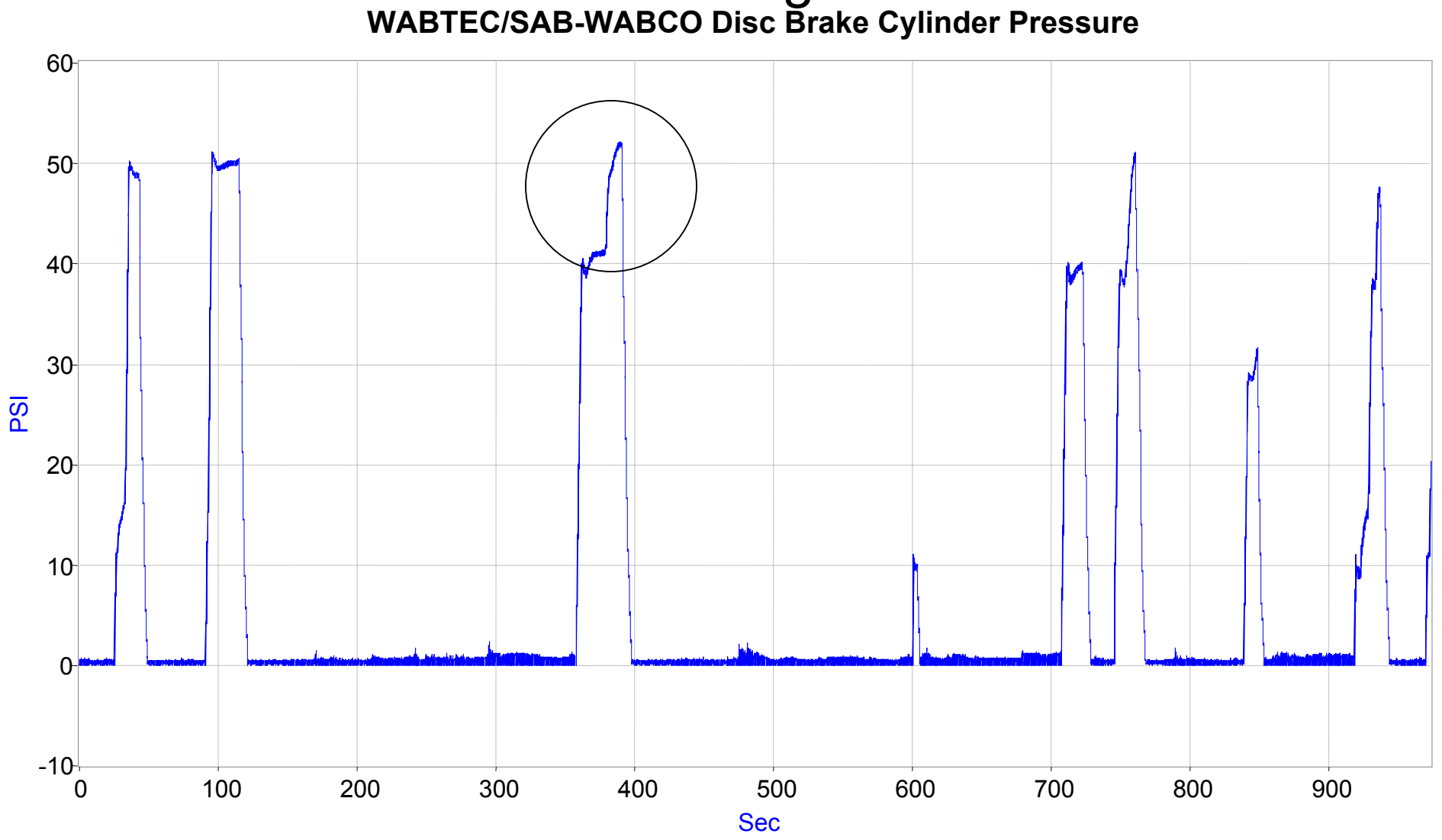
- All Under Braking Condition
- Brake Cylinder Pressure ~ 50 psi
- Instrumented Axle In Lead Position
  - During Sustained Oscillations
  - During Non-sustained Oscillations
- Instrumented Axle In Trail Position
  - During Non-sustained Oscillations

Table K.1. Examples Analyzed

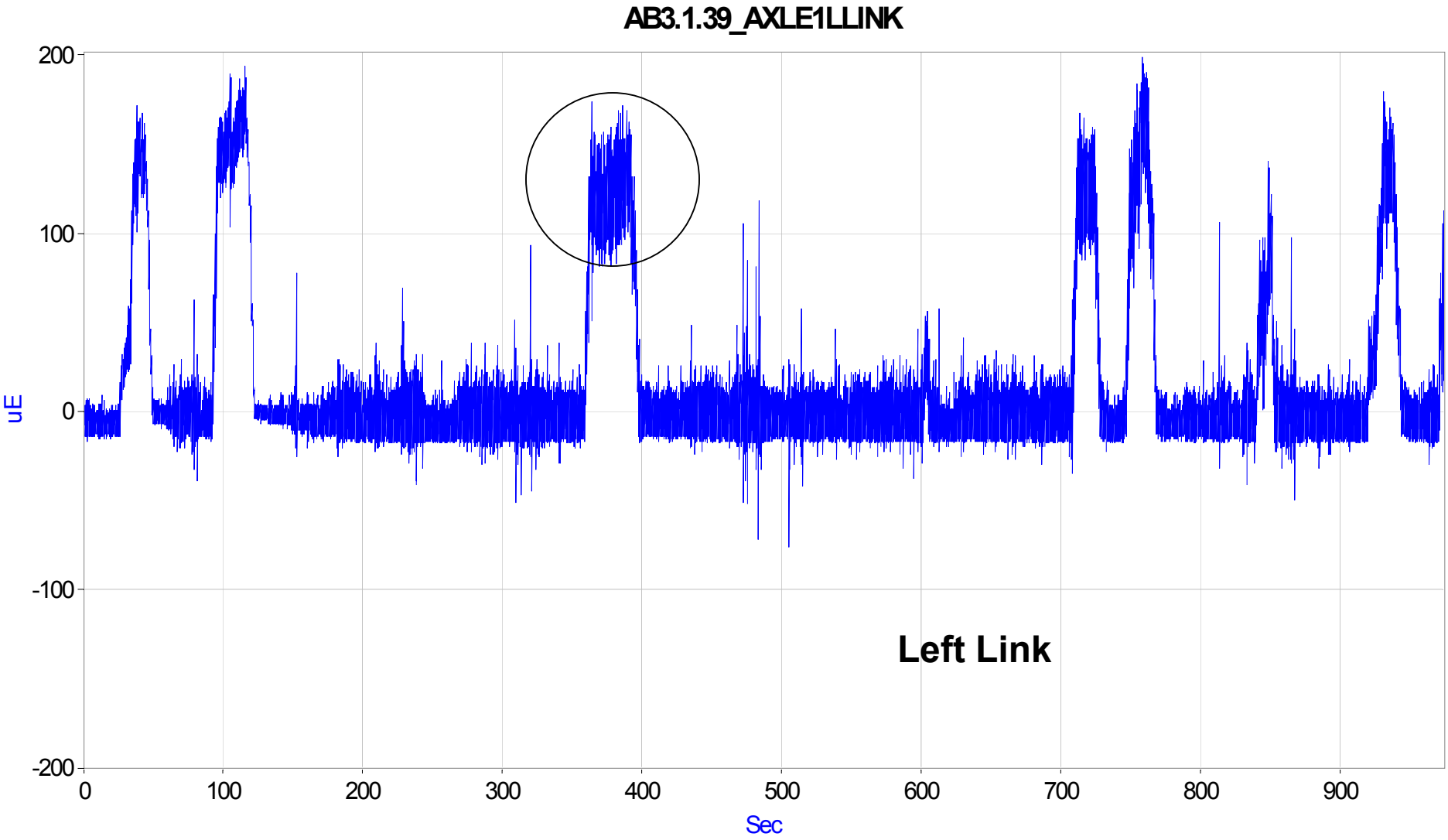
Date/File	Sustained Oscillation	Axle	Time in File Sec.	Speed mph
June 16 – File 18	No	Trail	375	94
June 18 – File 24	No	Lead	310	117
June 18 – File 24	yes	Lead	580	110
June 17 – File 25	Yes	Lead	559	69

June 16 – File 18
Braking
No Sustained Oscillations
Axle Trailing
t = 375 seconds
Speed = 94 mph

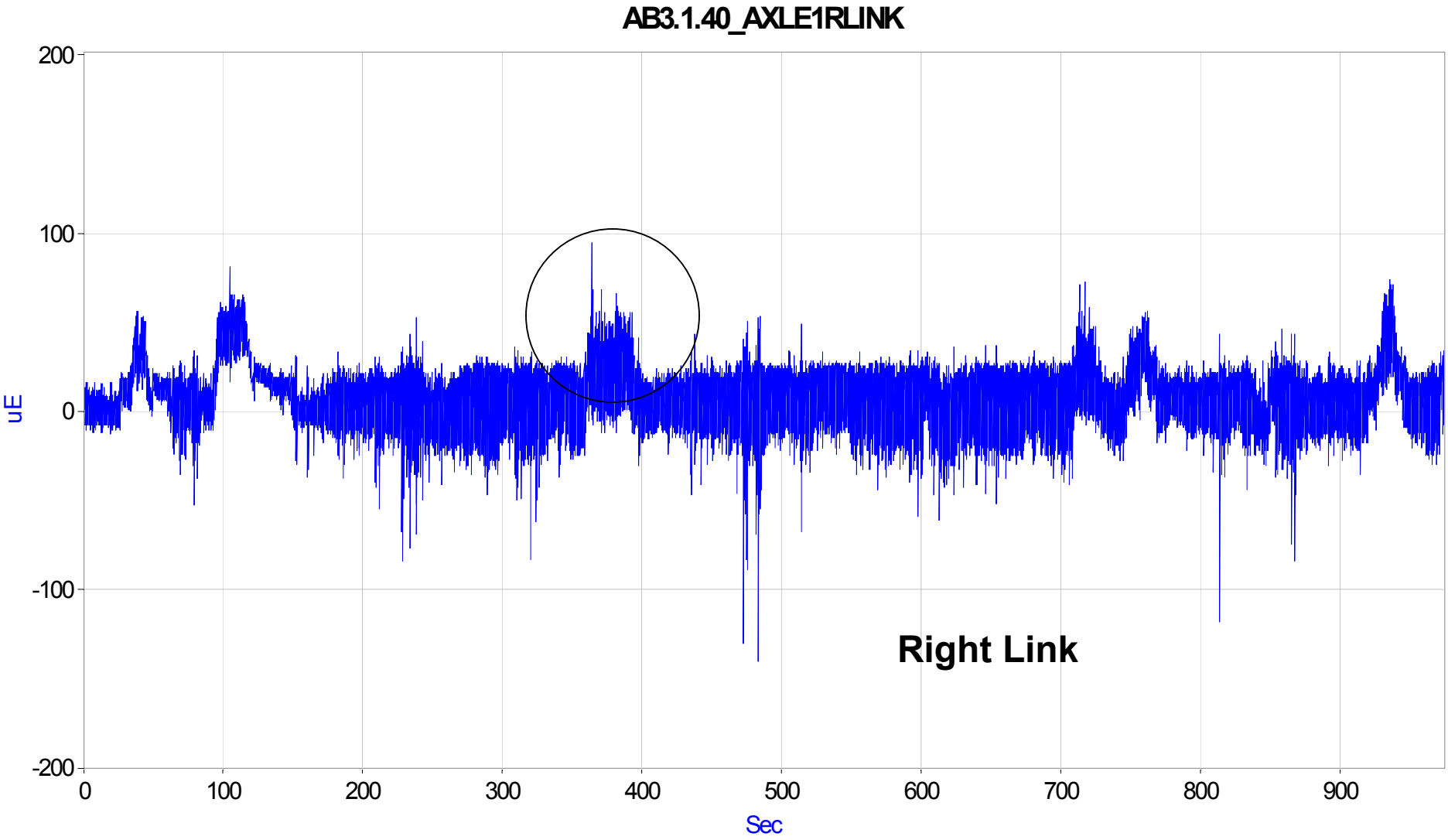
June 16 – File 18 – 375 seconds Braking, No Sustained Oscillations and Axle Trailing



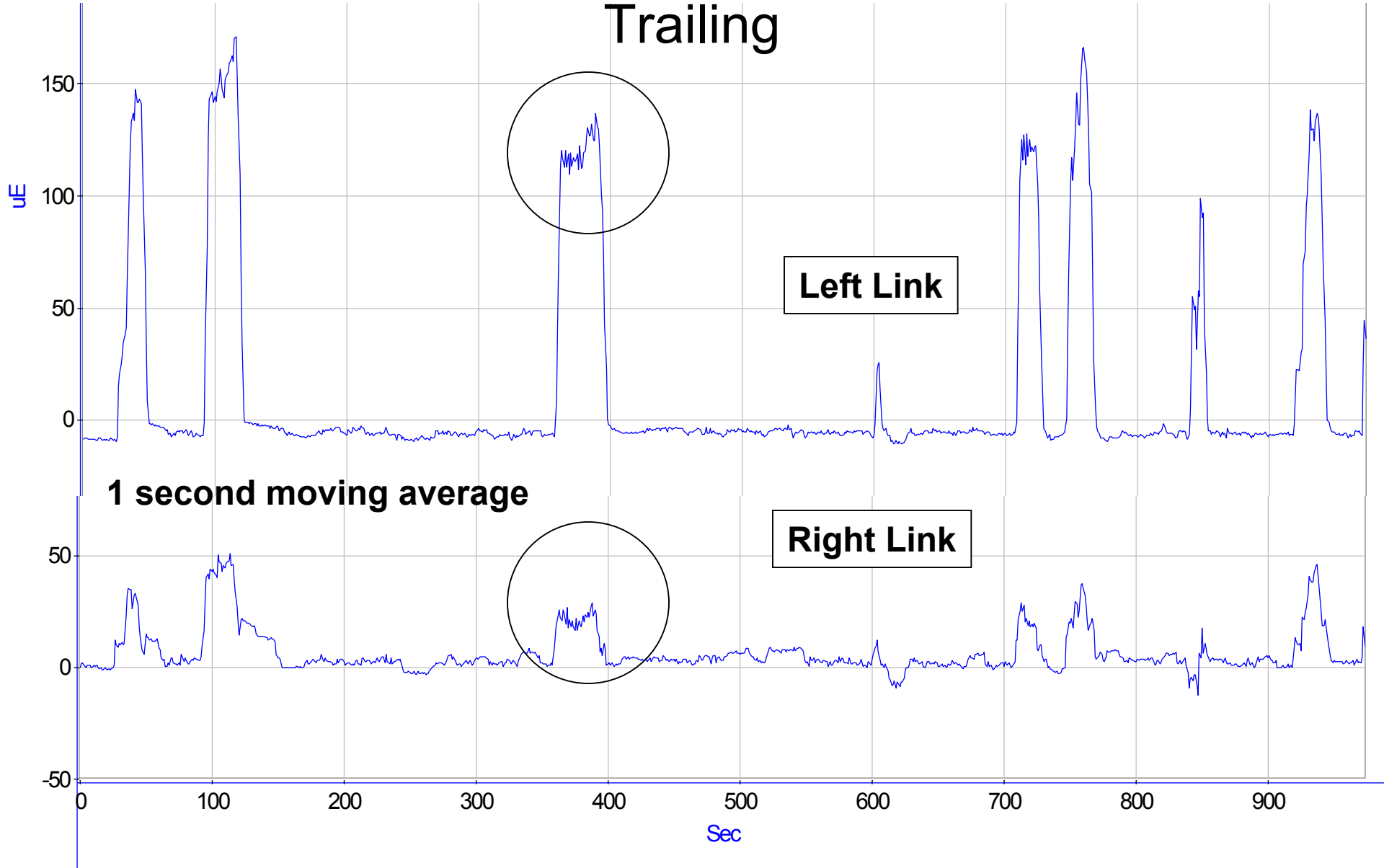
June 16 – File 18 – 375 seconds Braking, No Sustained Oscillations and Axle Trailing



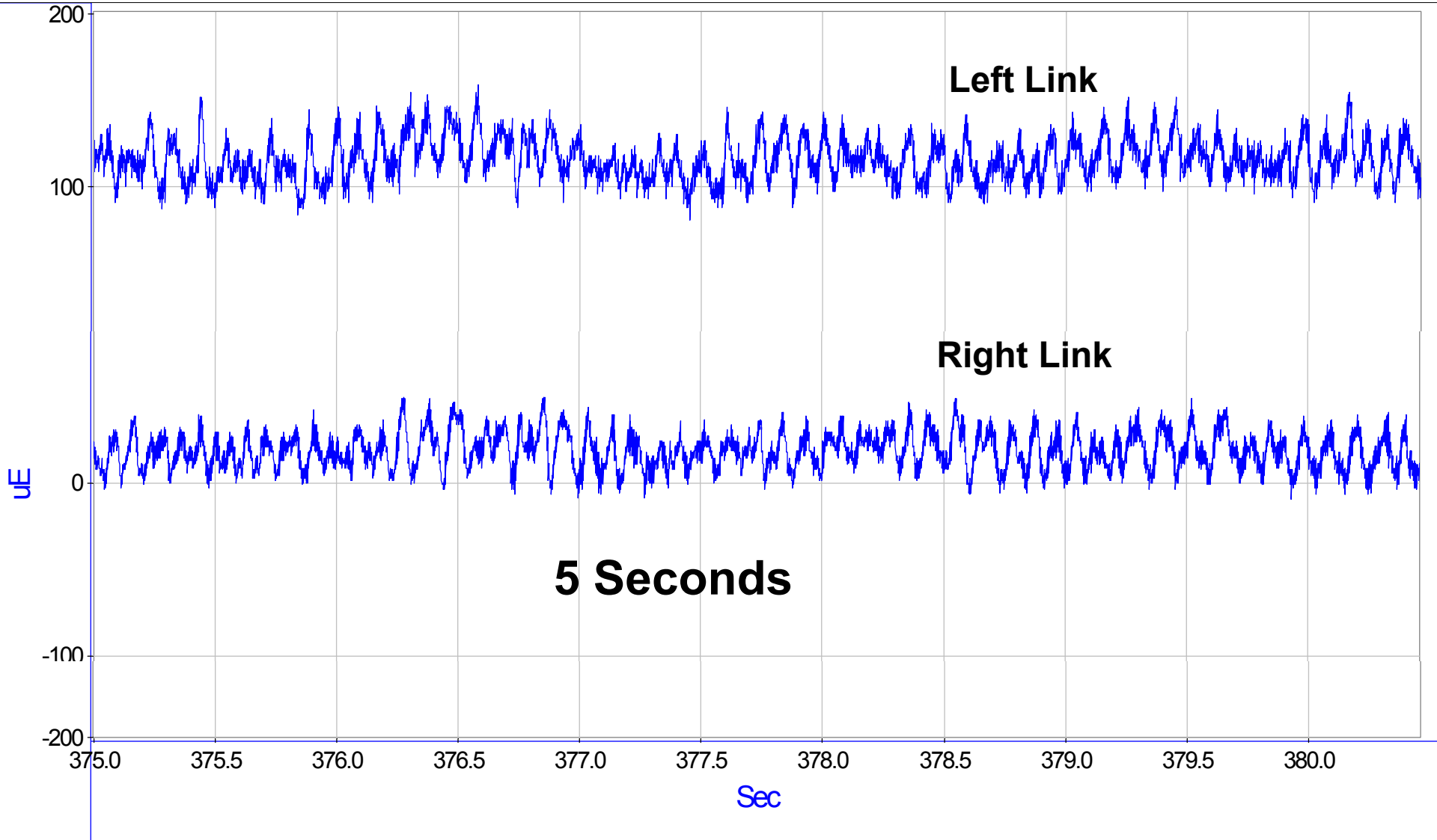
June 16 – File 18 – 375 seconds
Braking, No Sustained Oscillations and Axle Trailing



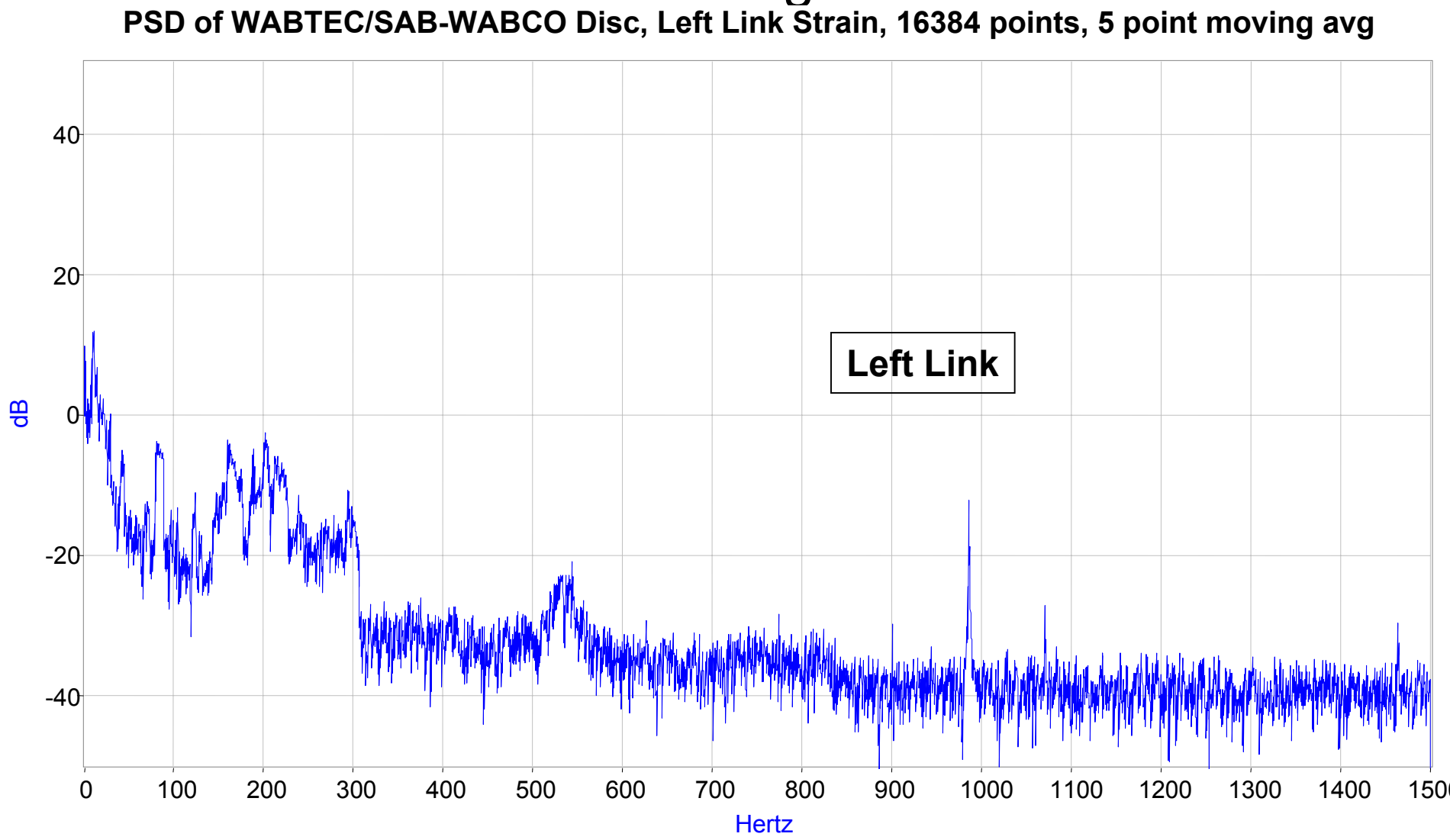
June 16 – File 18 – 375 seconds
Braking, No Sustained Oscillations and Axle Trailing



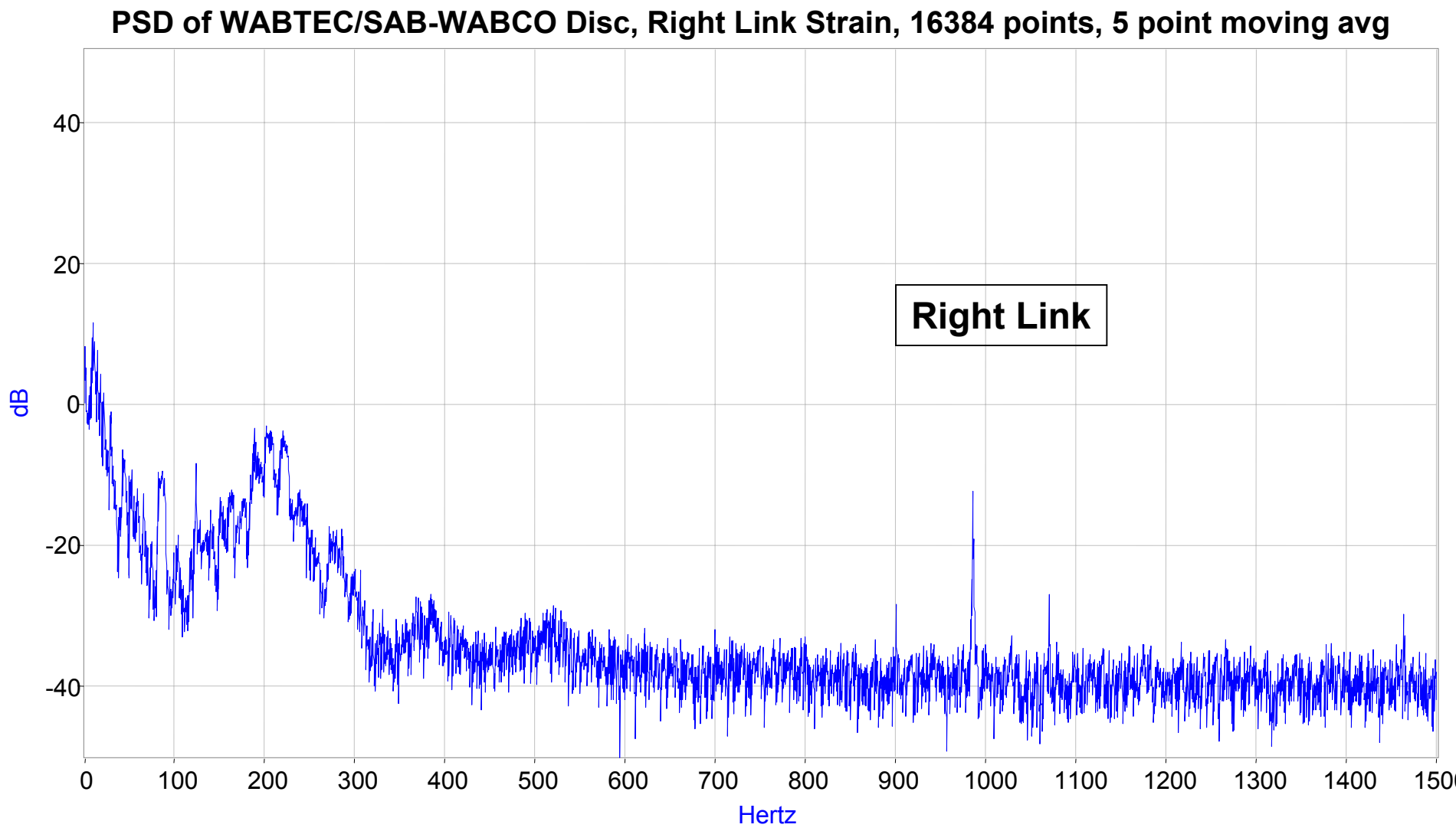
June 16 – File 18 – 375 seconds
Braking, No Sustained Oscillations and Axle Trailing



June 16 – File 18 – 375 seconds Braking, No Sustained Oscillations and Axle Trailing



June 16 – File 18 – 375 seconds Braking, No Sustained Oscillations and Axle Trailing



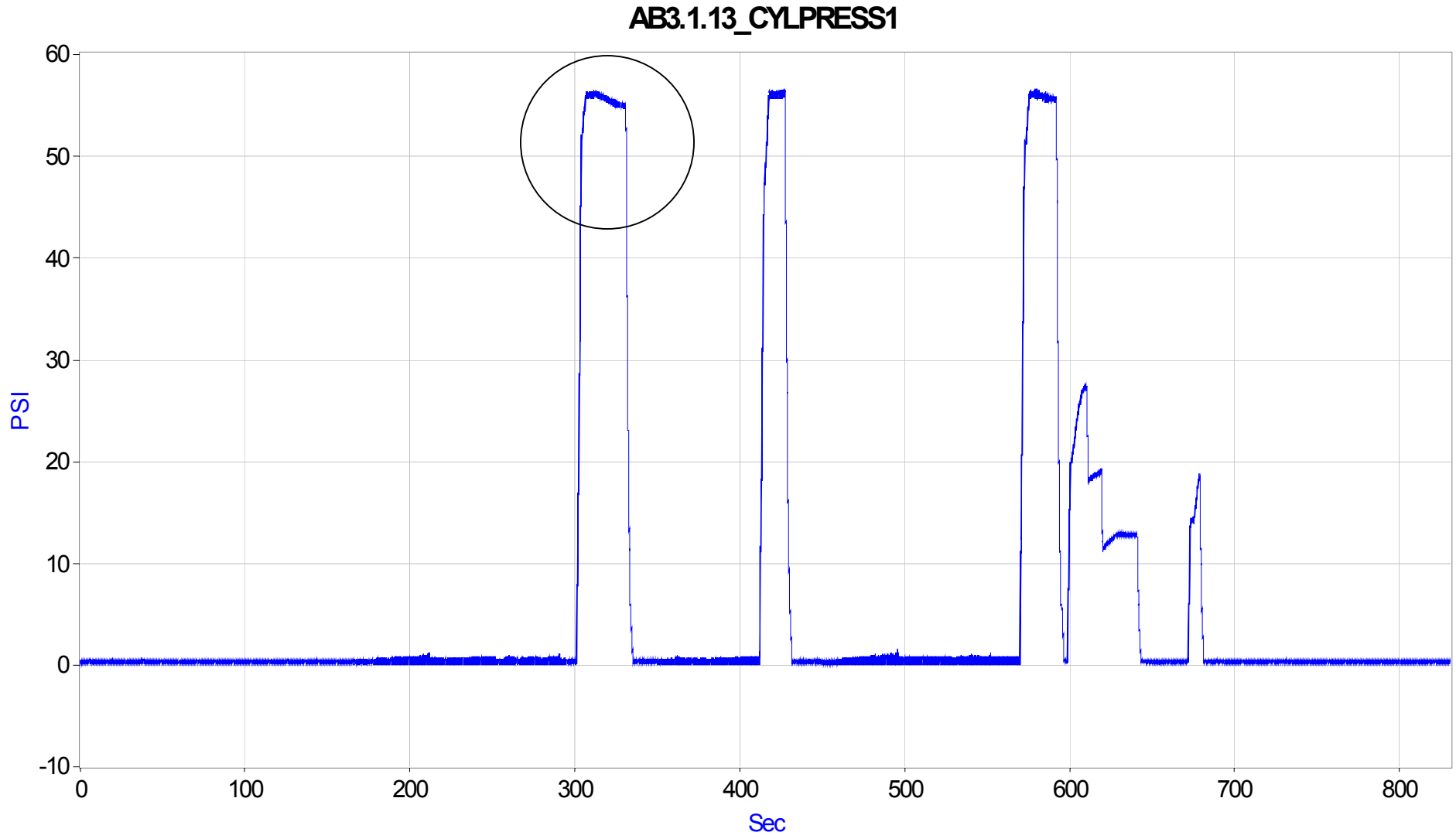
June 16 – File 18 – 375 seconds
Braking, No Sustained Oscillations and Axle Trailing

Date /File/ time	Sustained Oscillation	Axle	Harmonic Content	Strain Change
June 16 – File 18 -375	No	Trail	No	Tension

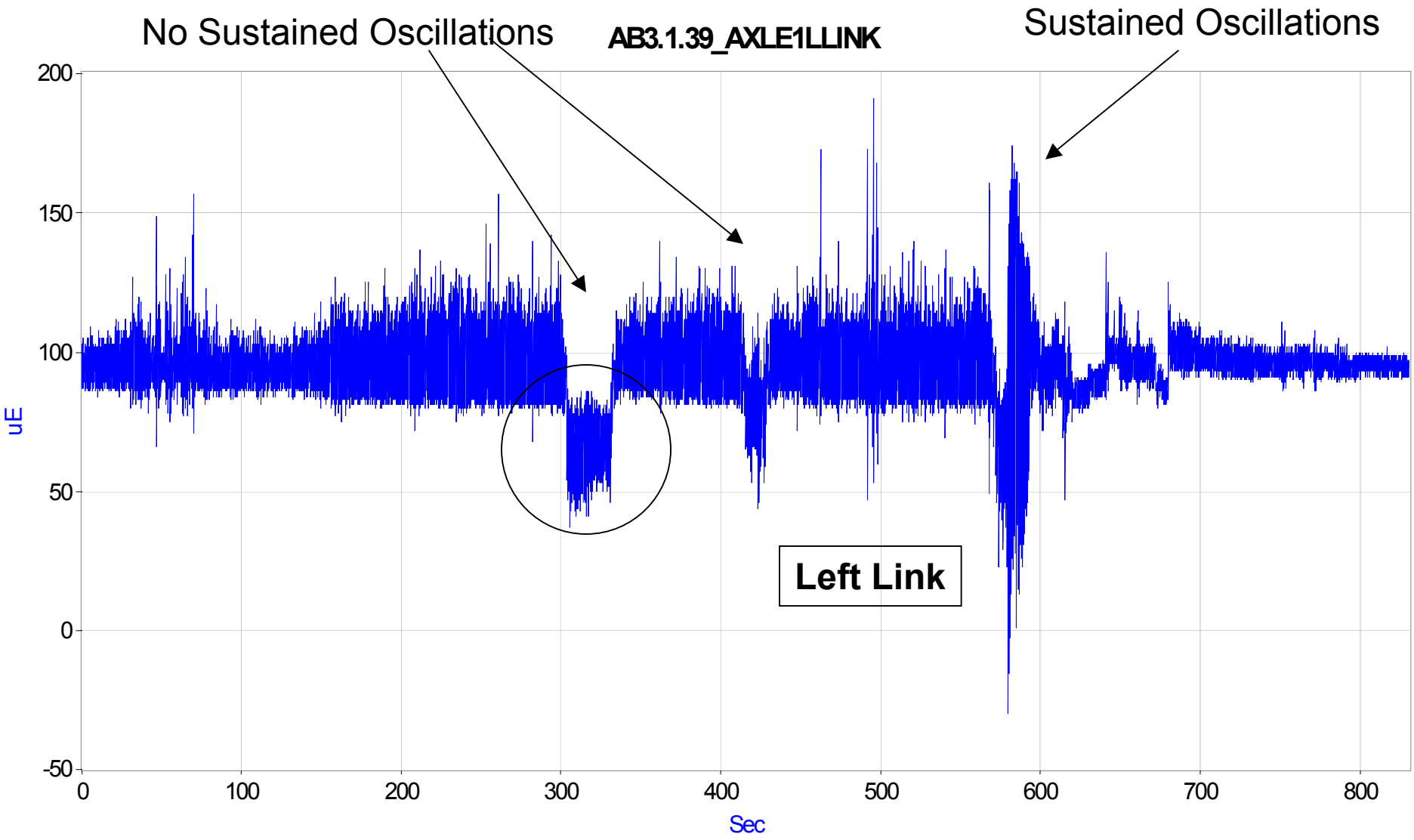
Date / File/ time	Sustained Oscillation	Axle	Left Link microstrain	Right Link microstrain
June 16 – File 18 -375	No	Trail	+130	+21

June 18 – File 24 Braking
No Sustained Oscillations
Instrumented Axle in Lead
t = 310 seconds
Speed = 117 mph

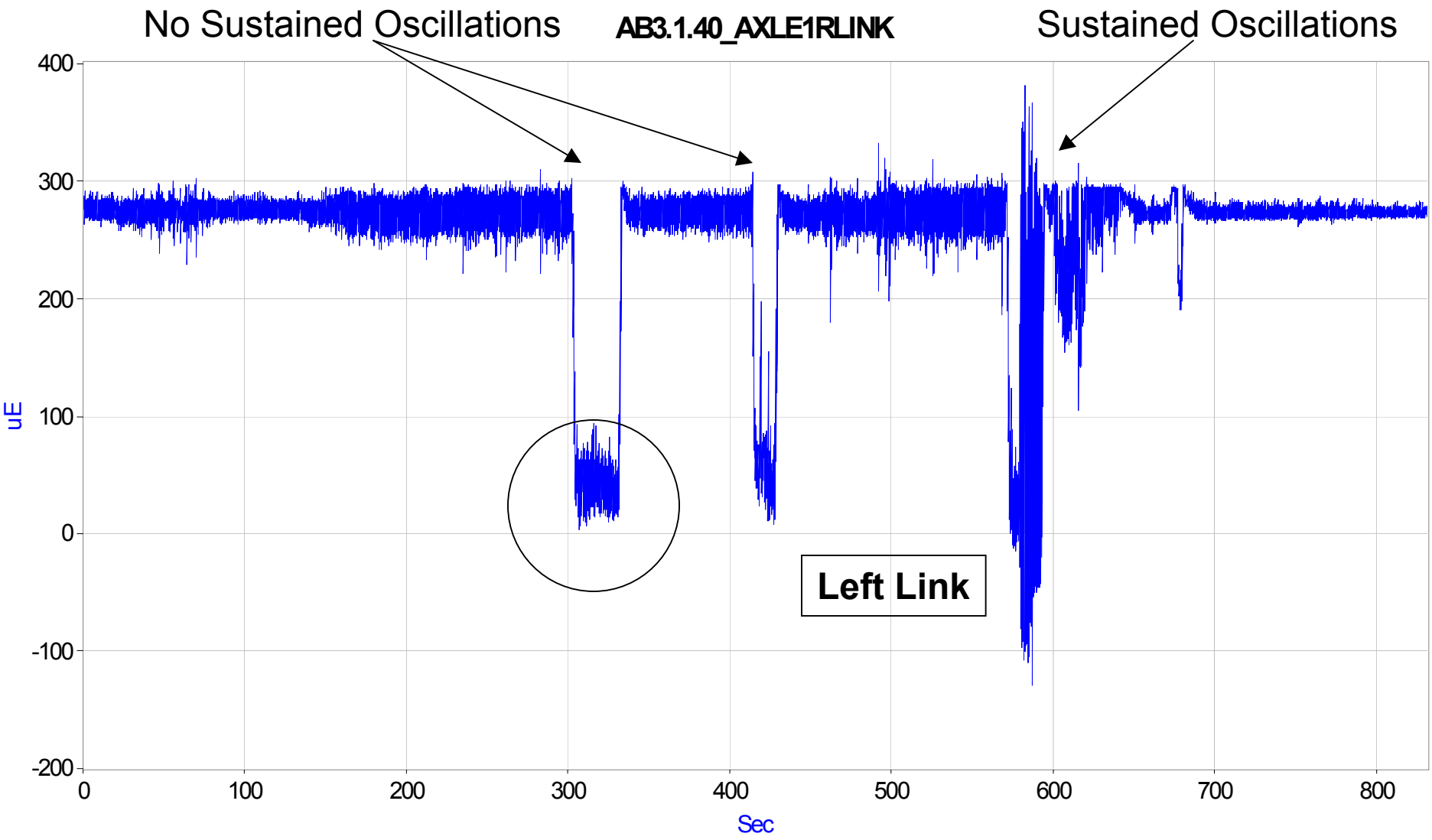
June 18 – File 24 – 310 seconds Braking, No Sustained Oscillations Instrumented Axle in Lead



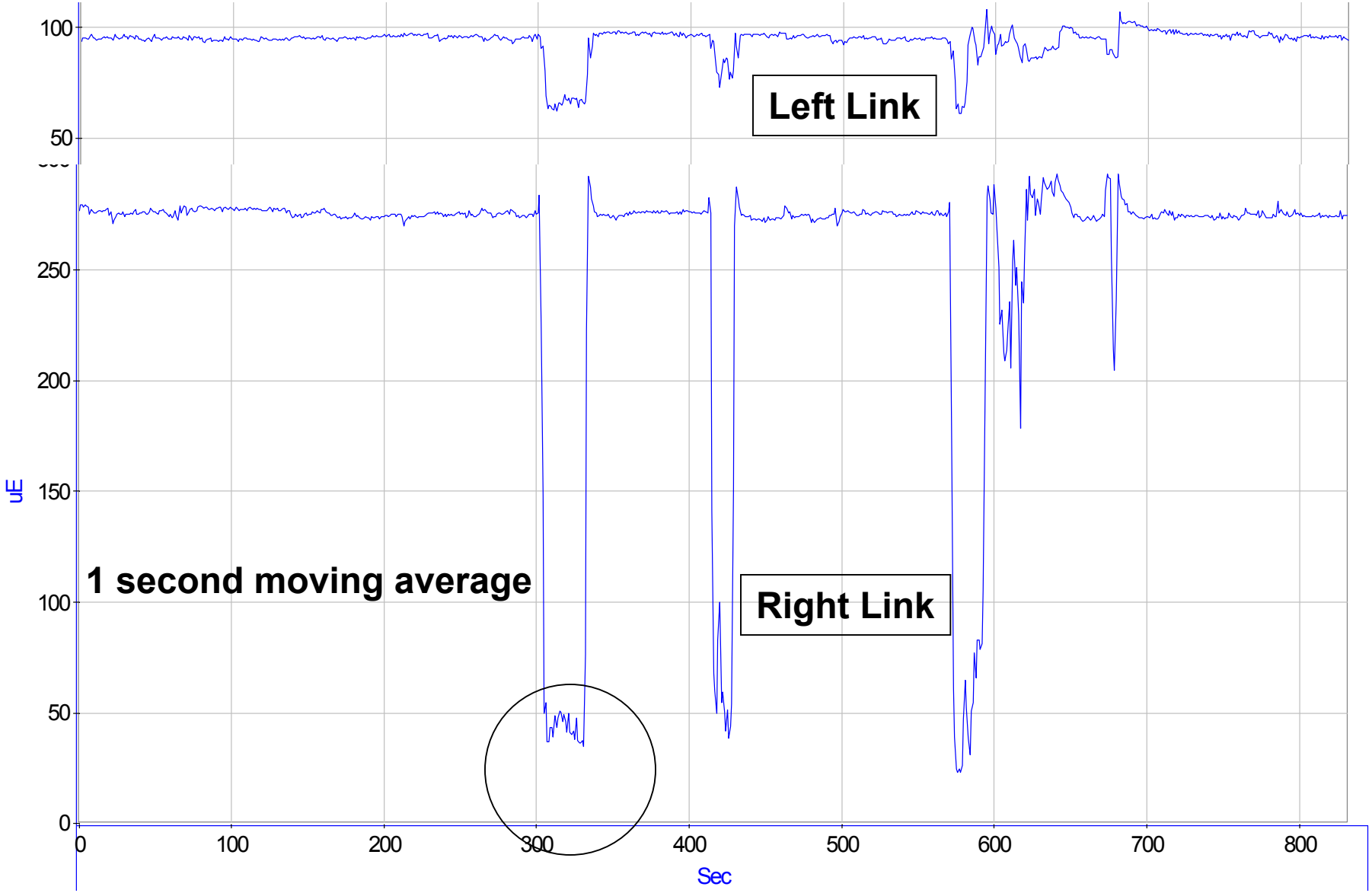
June 18 – File 24 – 310 seconds Braking, No Sustained Oscillations Instrumented Axle in Lead



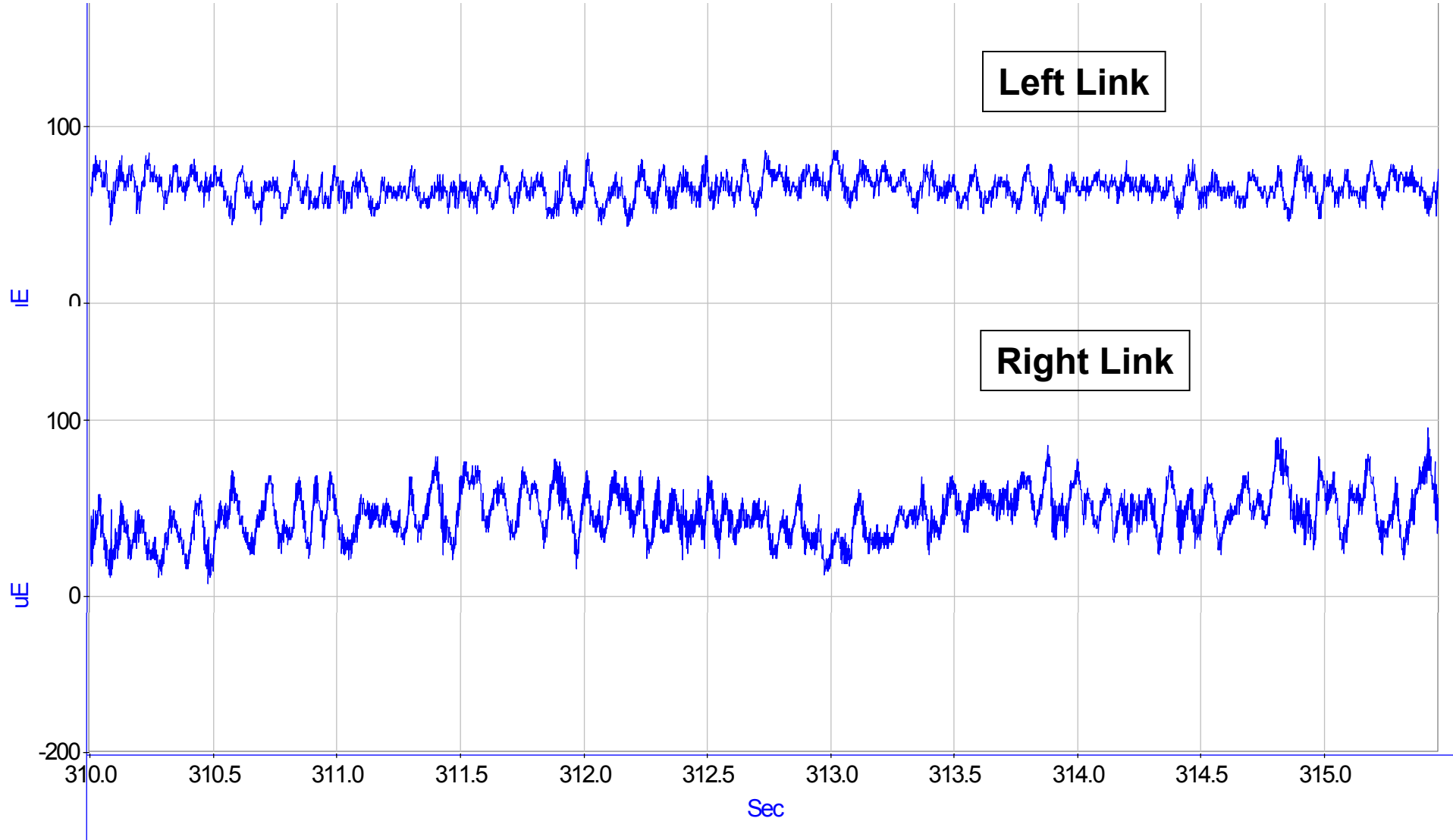
June 18 – File 24 – 310 seconds Braking, No Sustained Oscillations Instrumented Axle in Lead



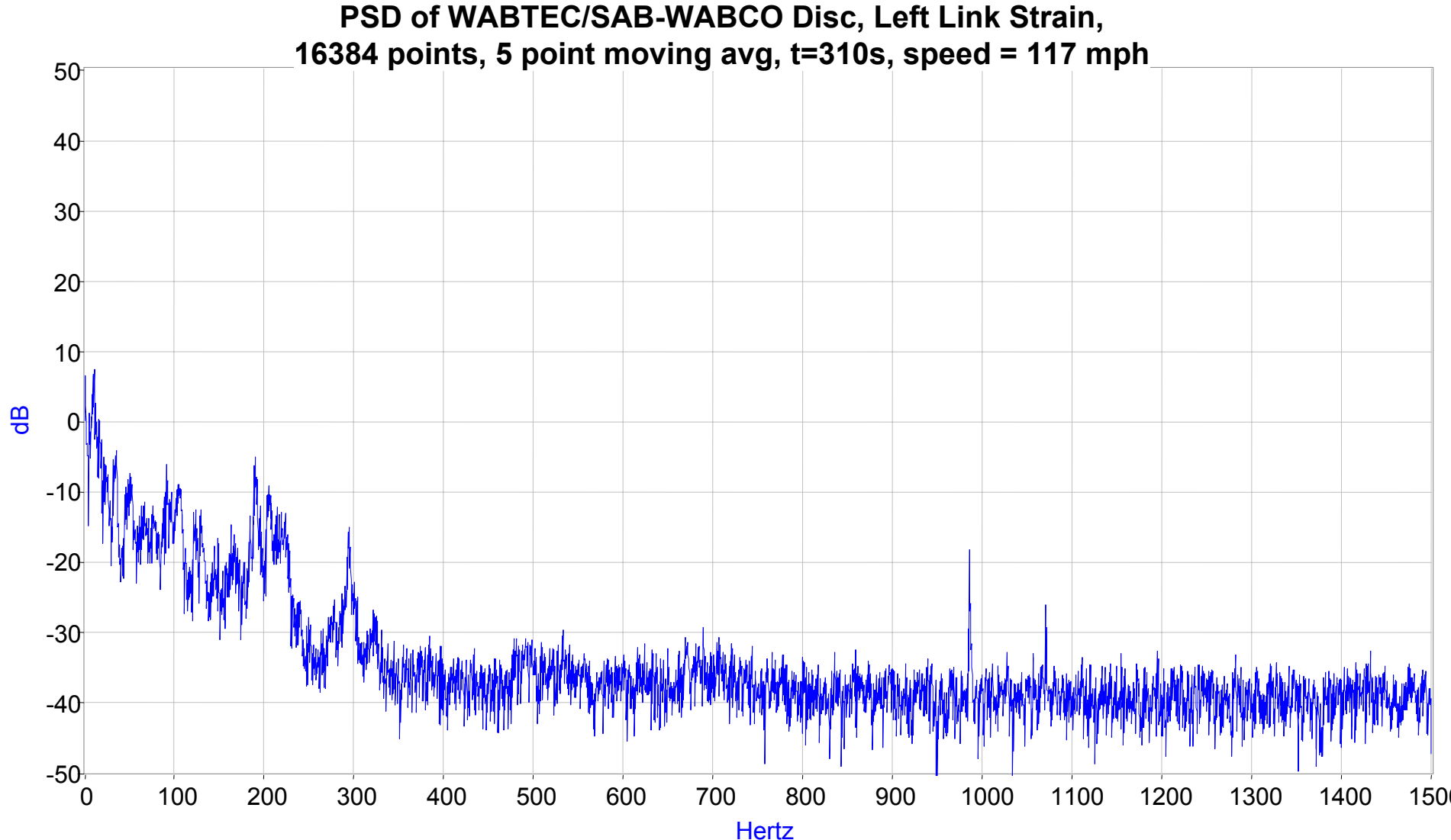
June 18 – File 24 – 310 seconds Braking, No Sustained Oscillations Instrumented Axle in Lead



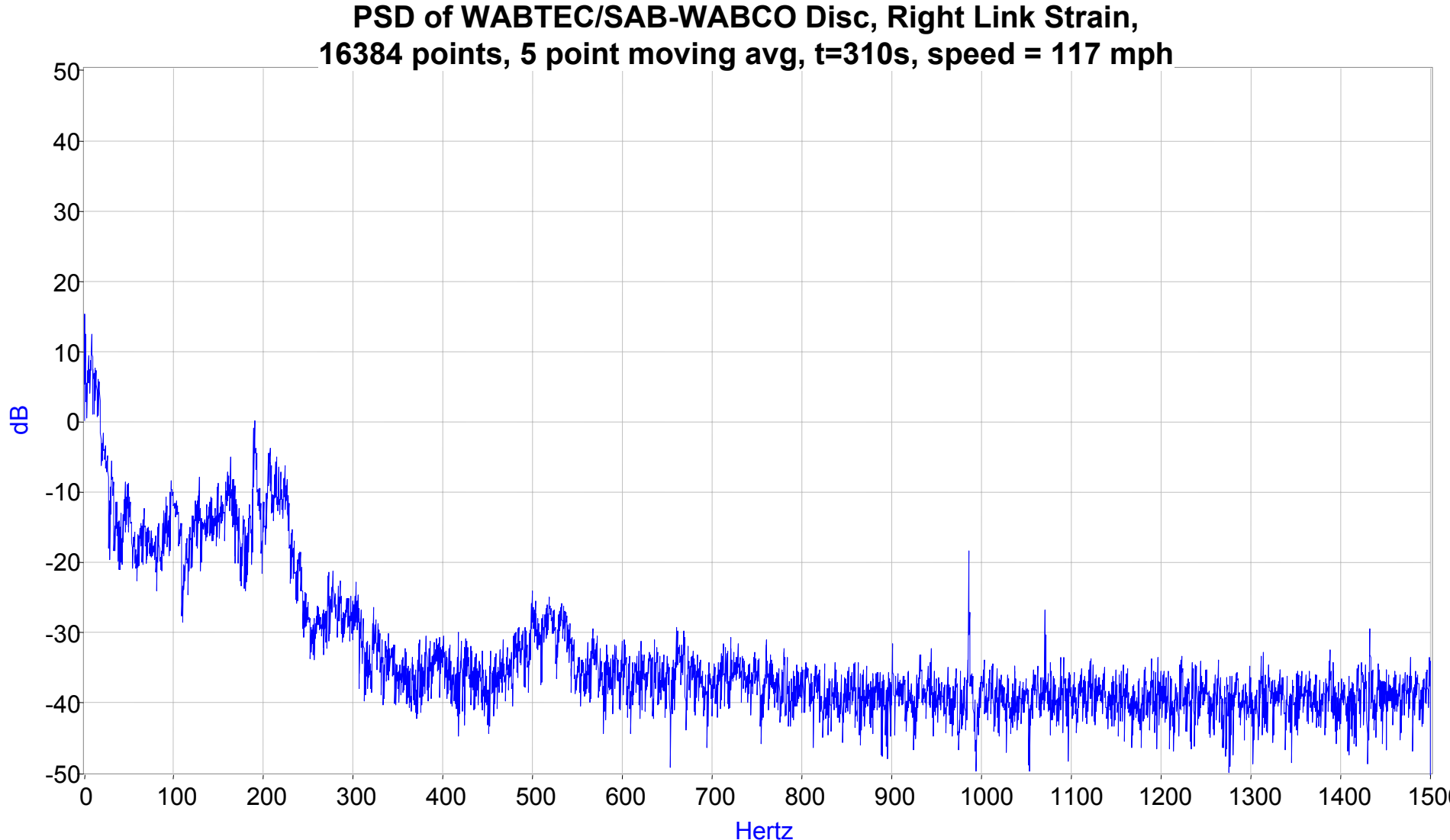
June 18 – File 24 – 310 seconds Braking, No Sustained Oscillations Instrumented Axle in Lead



June 18 – File 24 – 310 seconds Braking, No Sustained Oscillations Instrumented Axle in Lead



June 18 – File 24 – 310 seconds Braking, No Sustained Oscillations Instrumented Axle in Lead



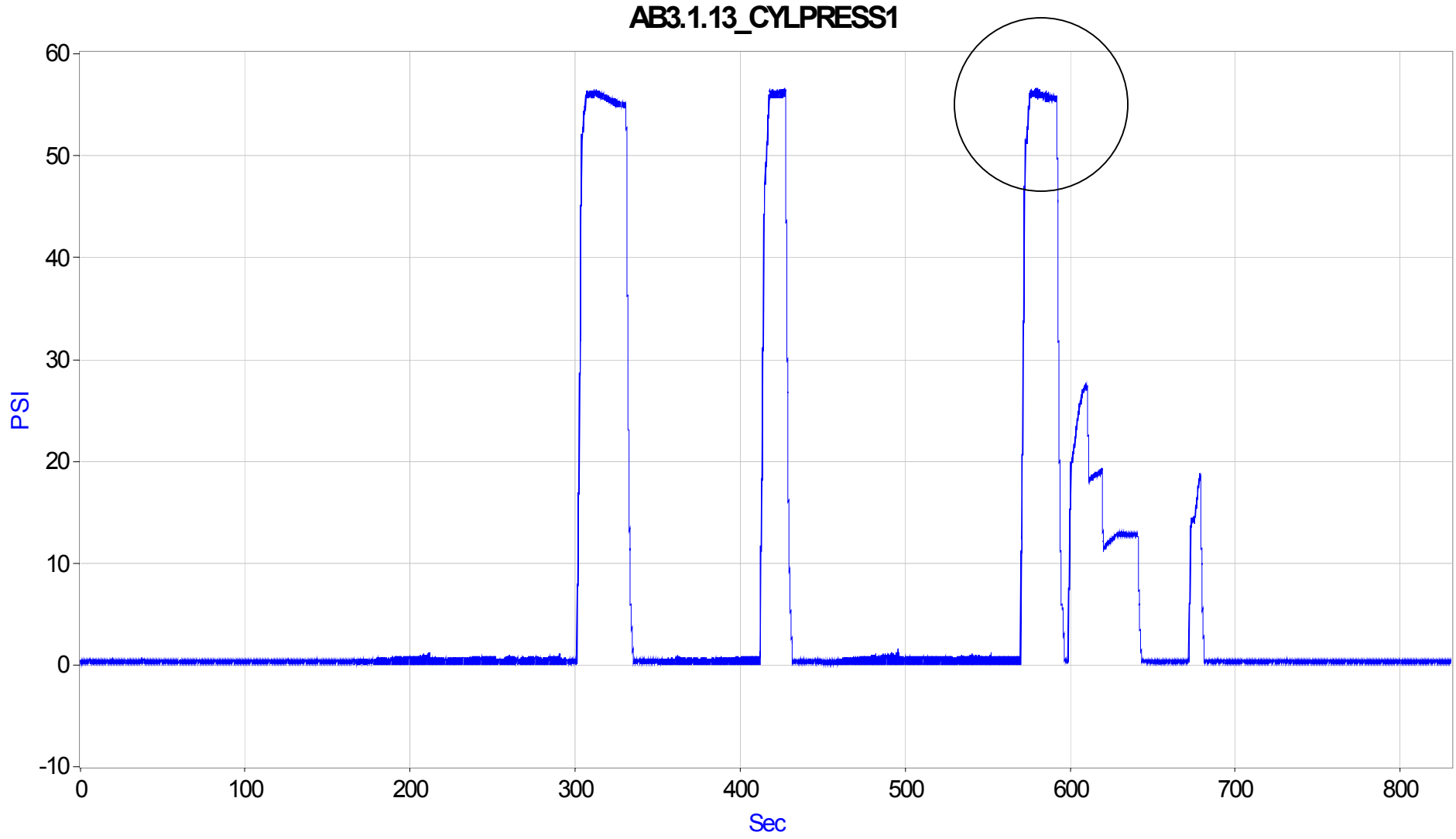
June 18 – File 24 – 310 seconds Braking, No Sustained Oscillations Instrumented Axle in Lead

Date / File/ time	Sustained Oscillation	Axle	Harmonic Content	Strain Change
June 18 – File 24 - 310	No	Lead	No	Compression

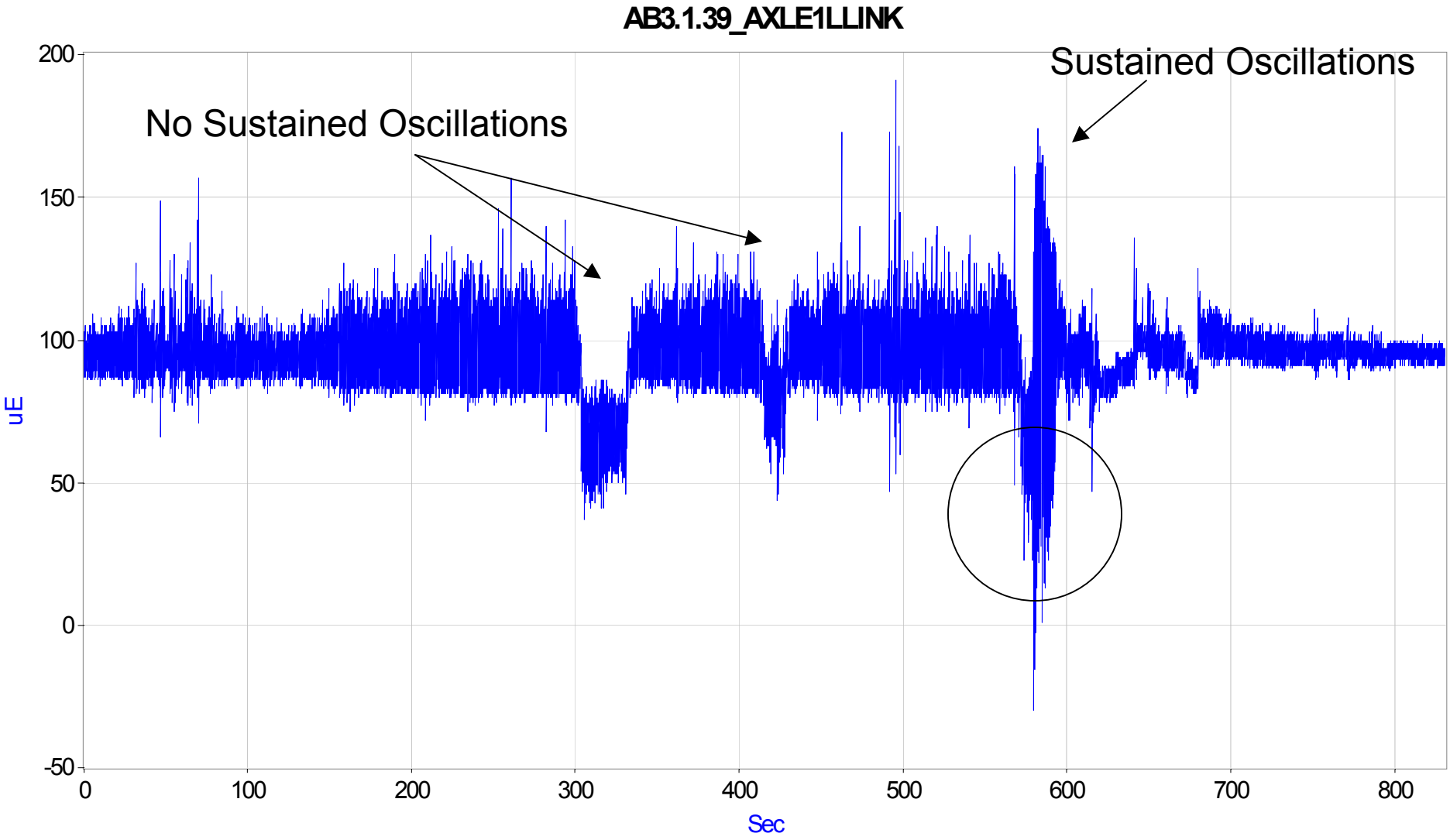
Date / File/ time	Sustained Oscillation	Axle	Left Link microstrain	Right Link microstrain
June 18 – File 24 - 310	No	Lead	-32	-231

June 18 – File 24
Braking
Sustained Oscillations
Instrumented Axle in Lead
t = 580 seconds
Speed = 110mph

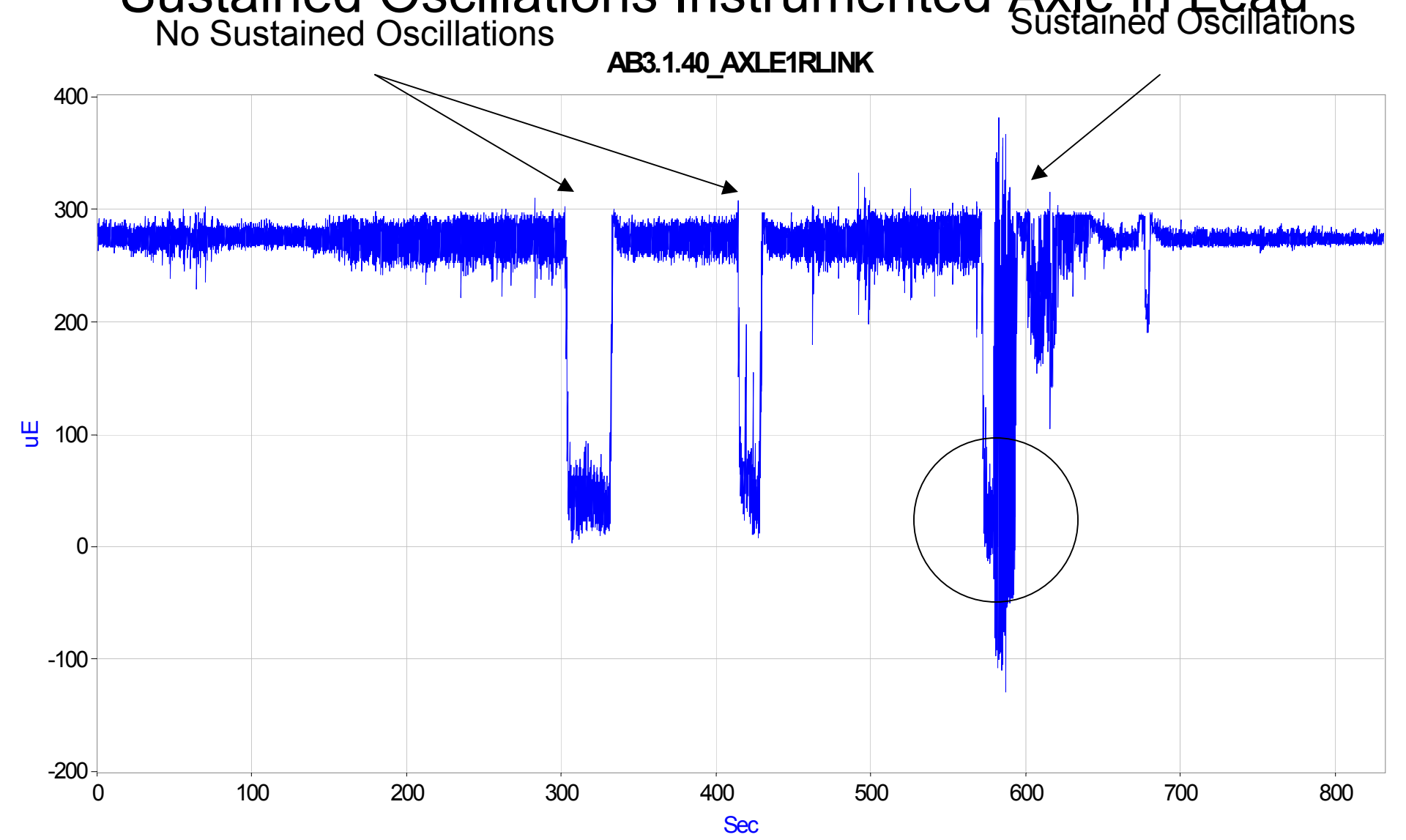
June 18 – File 24 -580 seconds
Braking
Sustained Oscillations Instrumented Axle in Lead



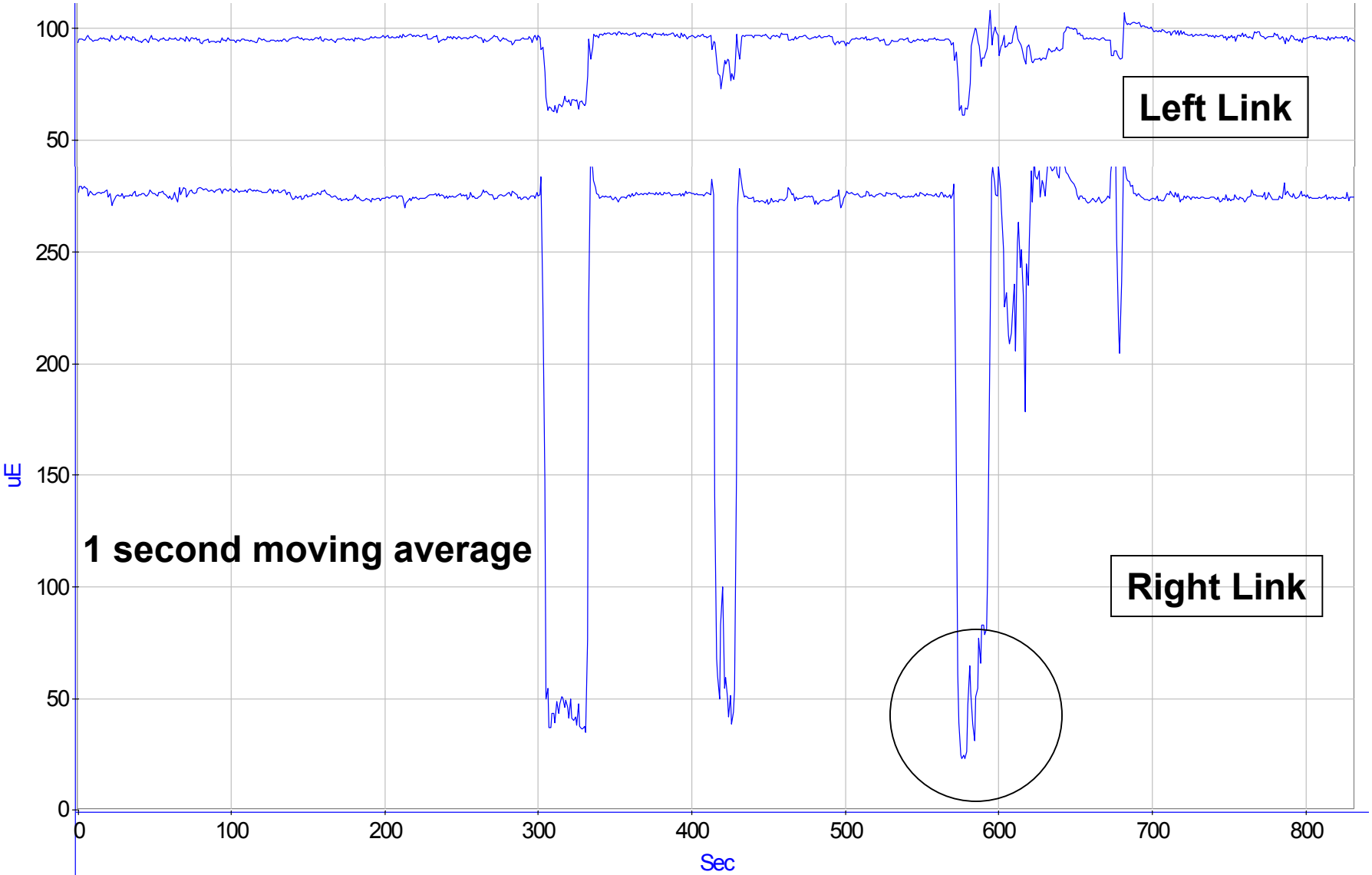
June 18 – File 24 -580 seconds
Braking
Sustained Oscillations Instrumented Axle in Lead



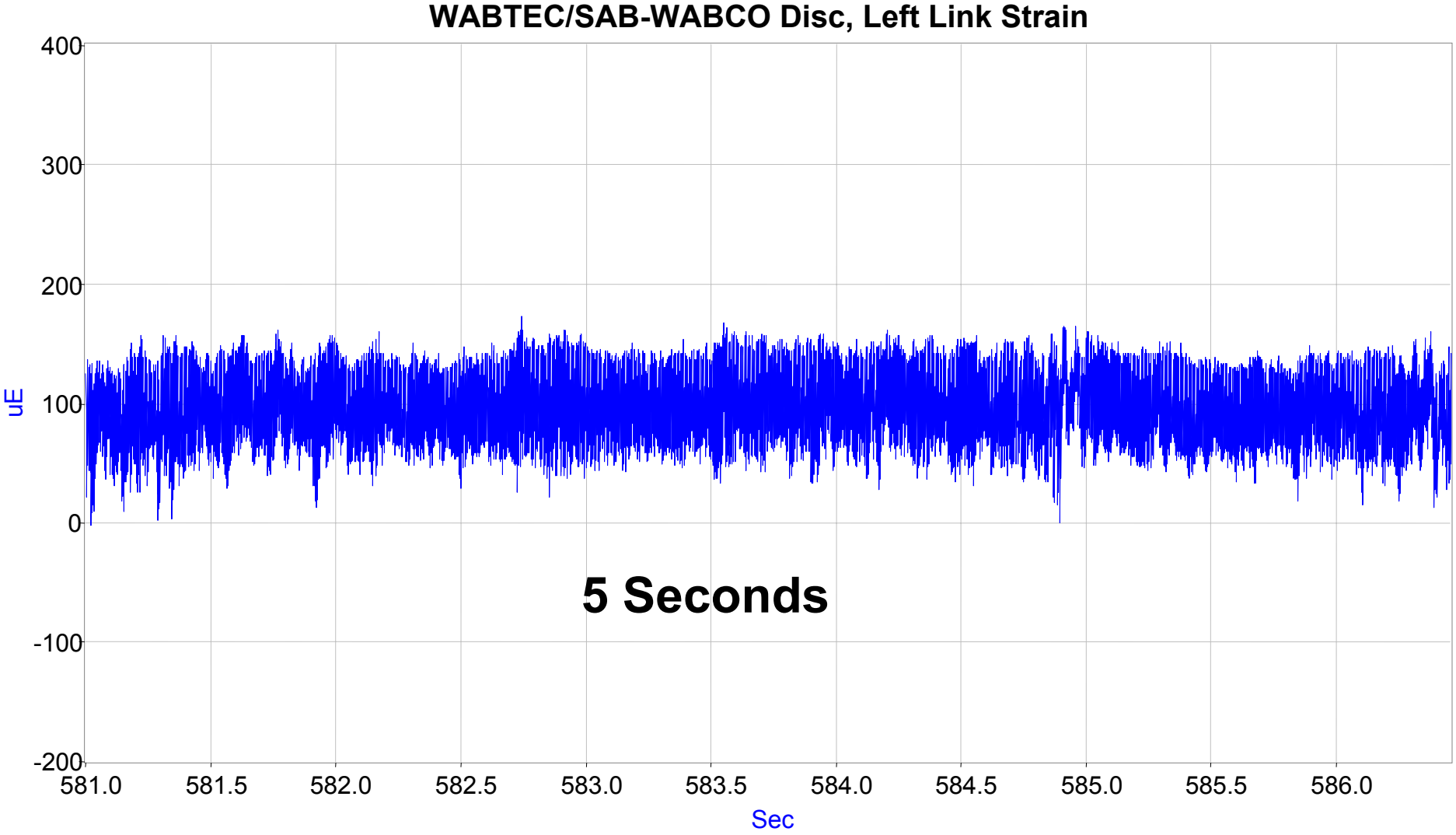
June 18 – File 24 -580 seconds
Braking
Sustained Oscillations Instrumented Axle in Lead



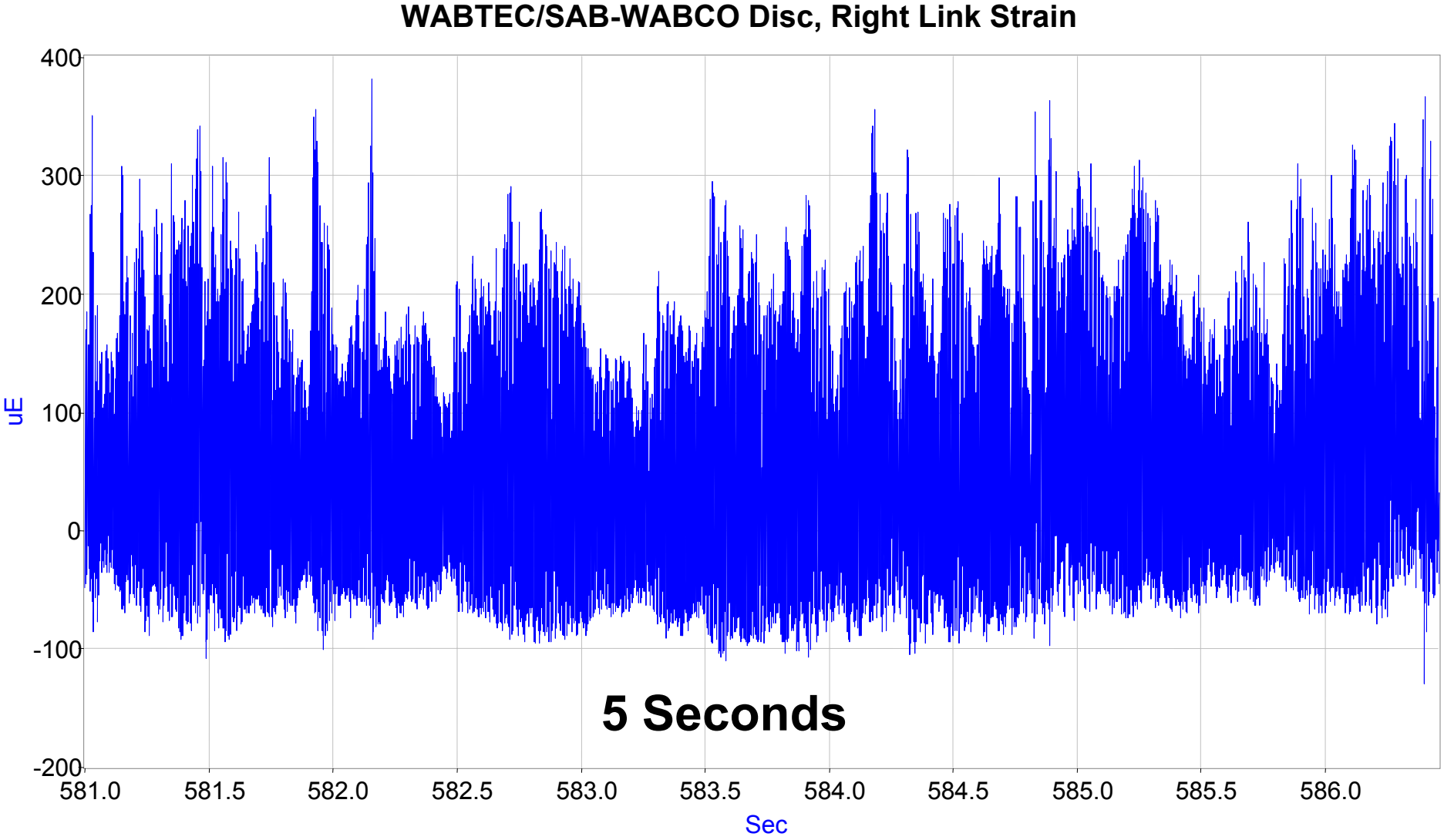
June 18 – File 24 -580 seconds
Braking
Sustained Oscillations Instrumented Axle in Lead



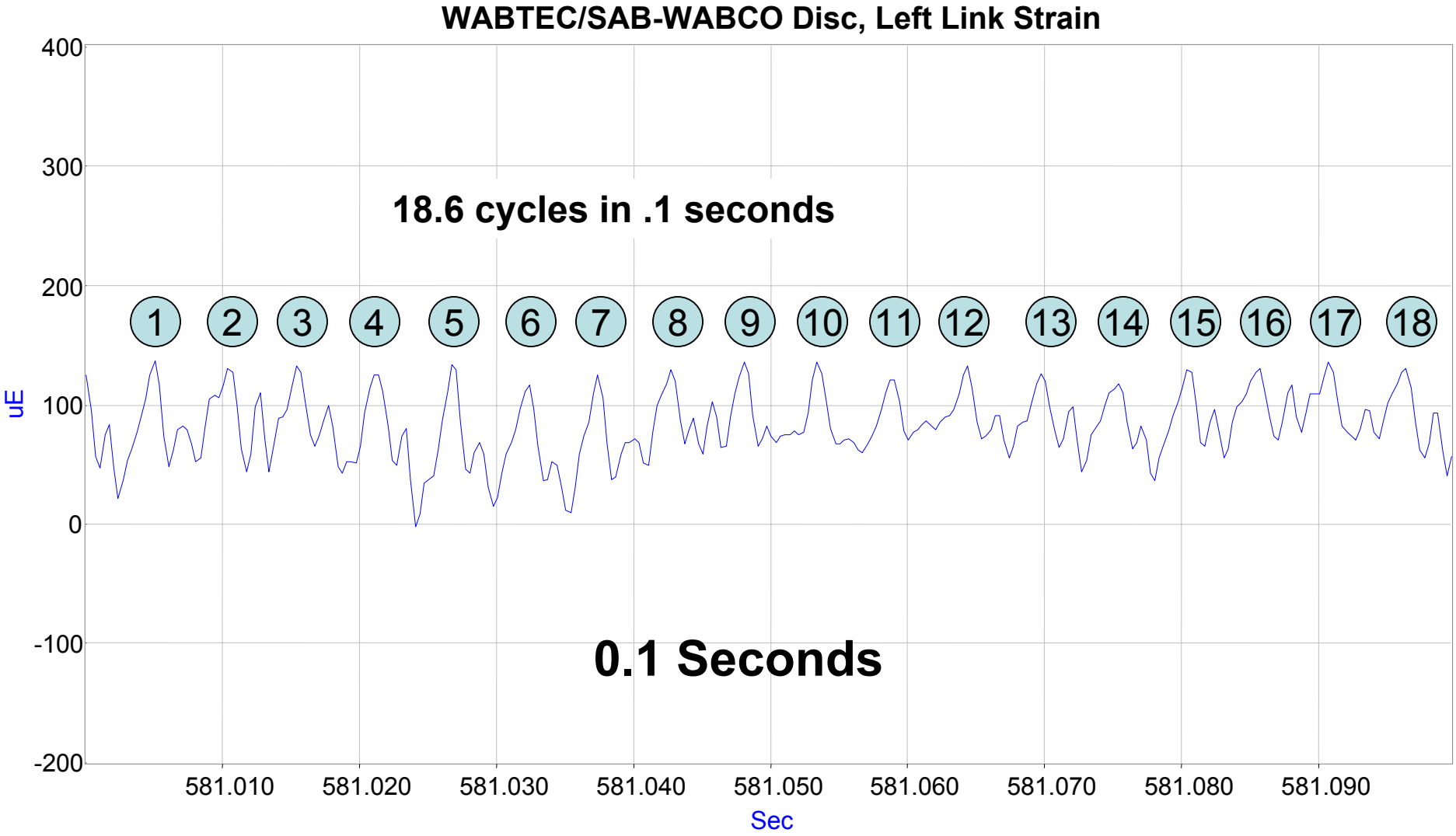
June 18 – File 24 -580 seconds
Braking
Sustained Oscillations Instrumented Axle in Lead



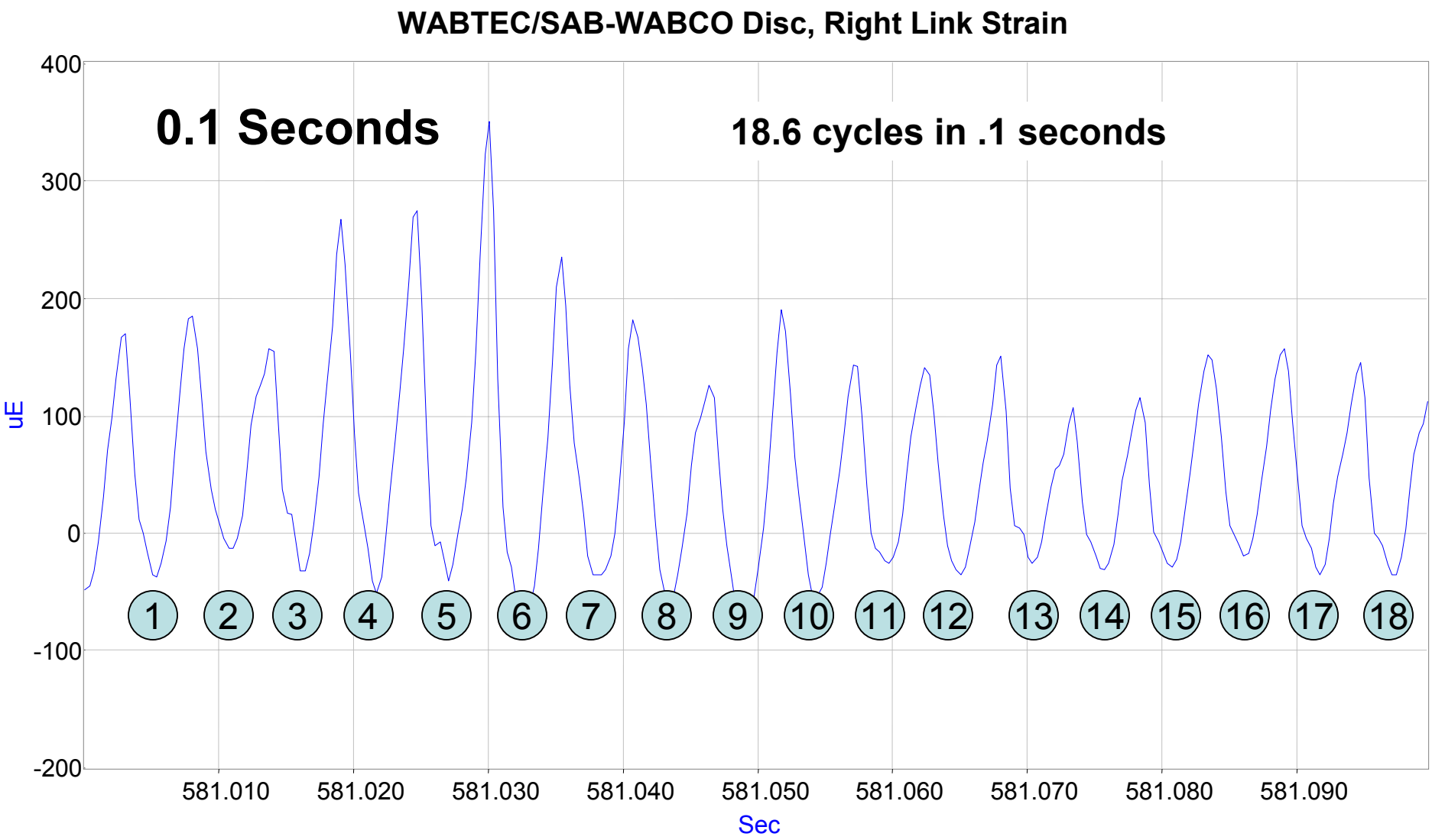
June 18 – File 24 -580 seconds
Braking
Sustained Oscillations Instrumented Axle in Lead



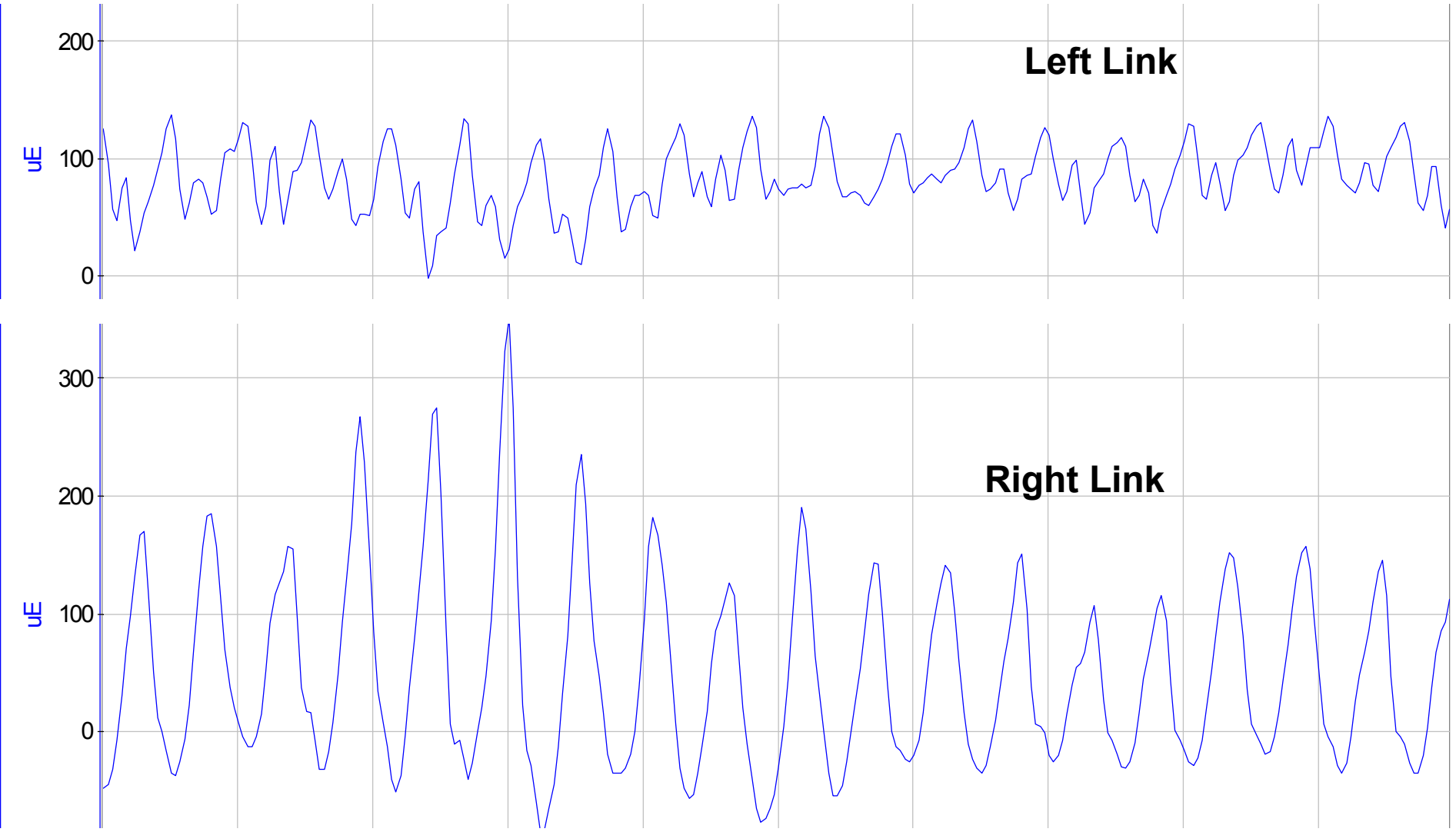
June 18 – File 24 -580 seconds
Braking
Sustained Oscillations Instrumented Axle in Lead



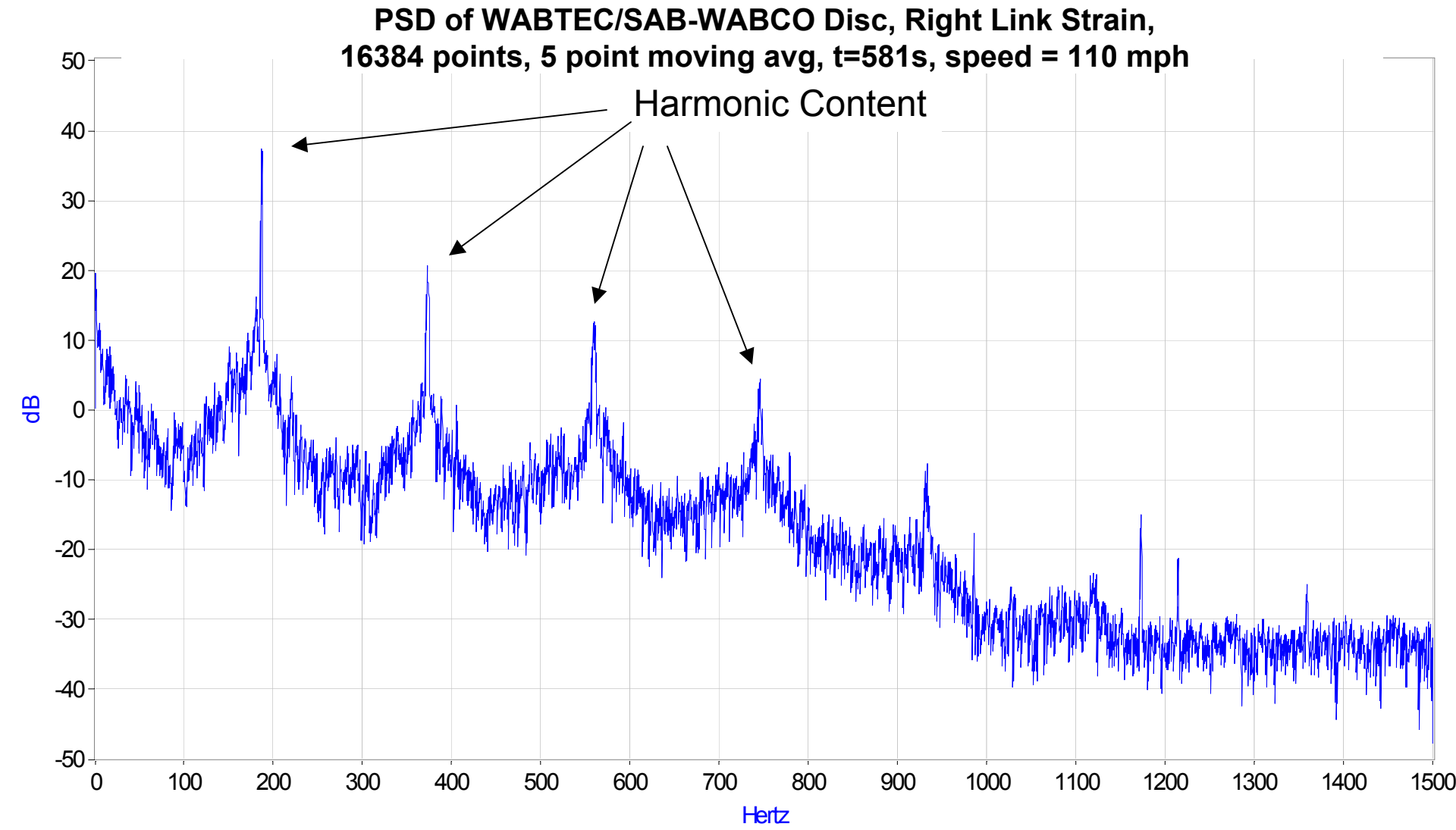
June 18 – File 24 (Brake, BOP)



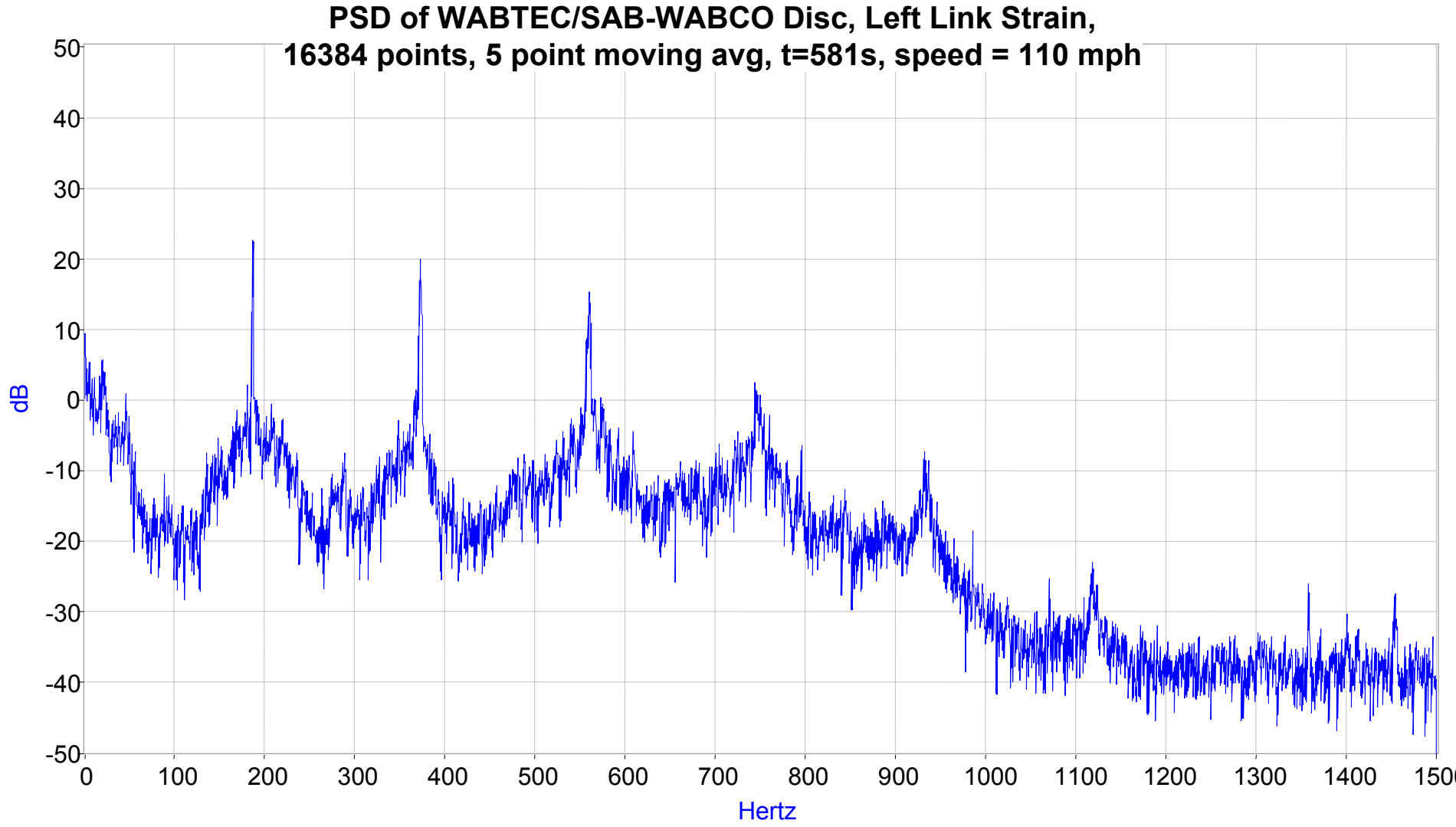
Links Out Of Phase



June 18 – File 24 -580 seconds
Braking
Sustained Oscillations Instrumented Axle in Lead



June 18 – File 24 -580 seconds
Braking
Sustained Oscillations Instrumented Axle in Lead



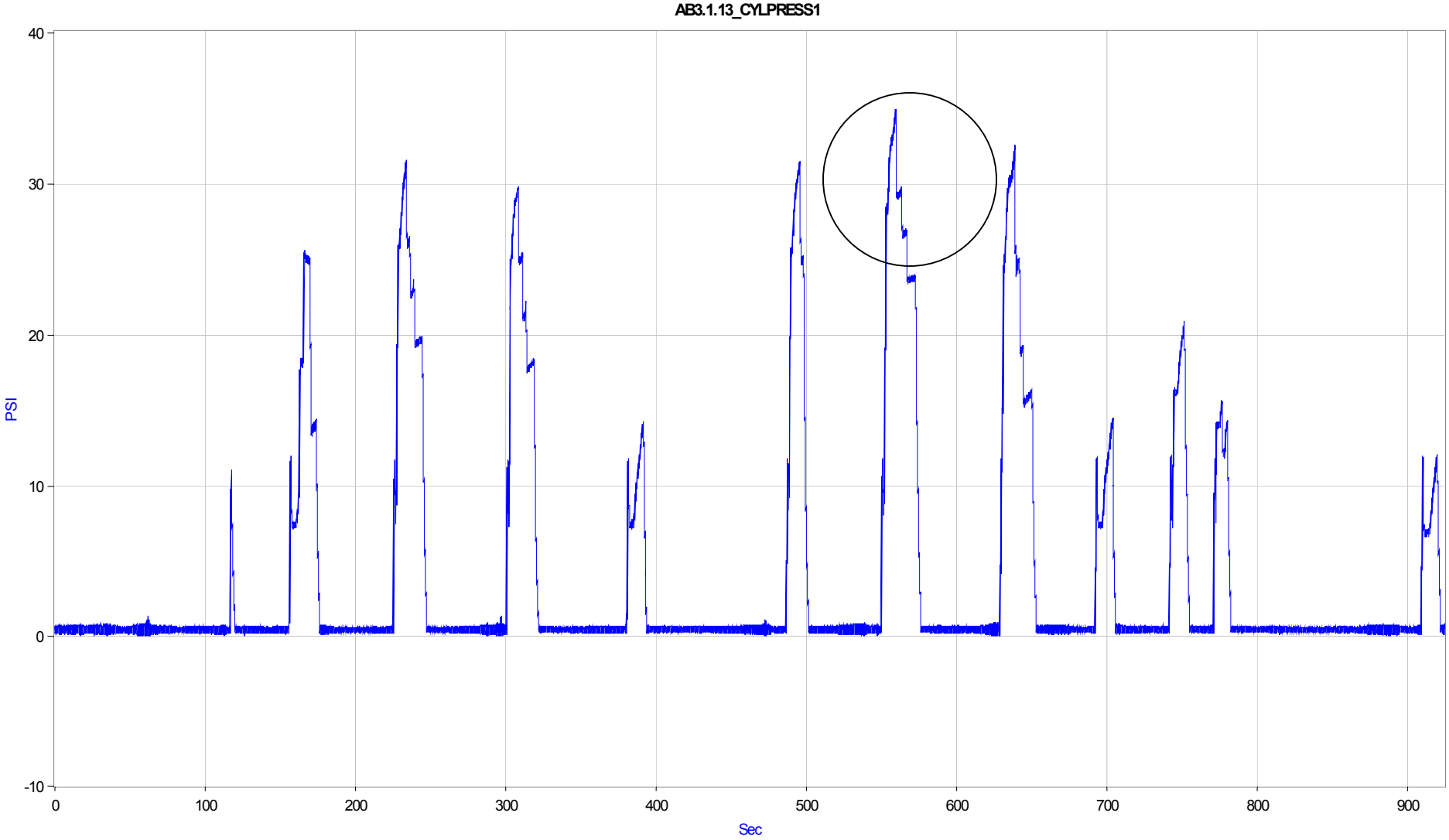
June 18 – File 24 -580 seconds
Braking
Sustained Oscillations Instrumented Axle in Lead

Date / File/ time	Sustained Oscillation	Axle	Harmonic Content	Strain Change
June 18 – File 24 -580	yes	Lead	Yes	Compression

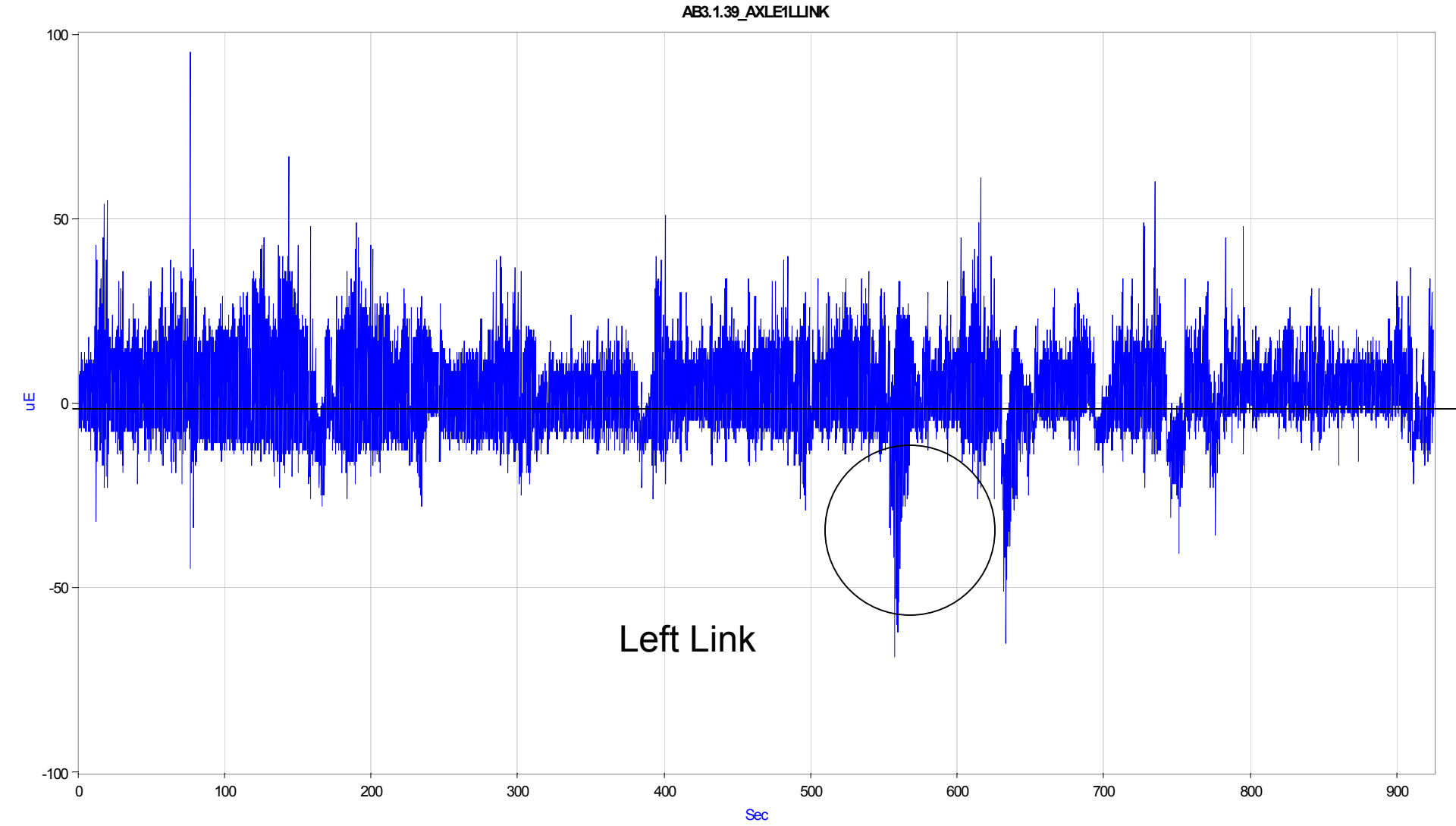
Date / File/ time	Sustained Oscillation	Axle	Left Link microstrain	Right Link microstrain
June 18 – File 24 -580	yes	Lead	-32	-221

June 17 – File 25
Braking
Sustained Oscillation
Instrumented Axle in Lead
Speed = 68 mph
T = 559 seconds

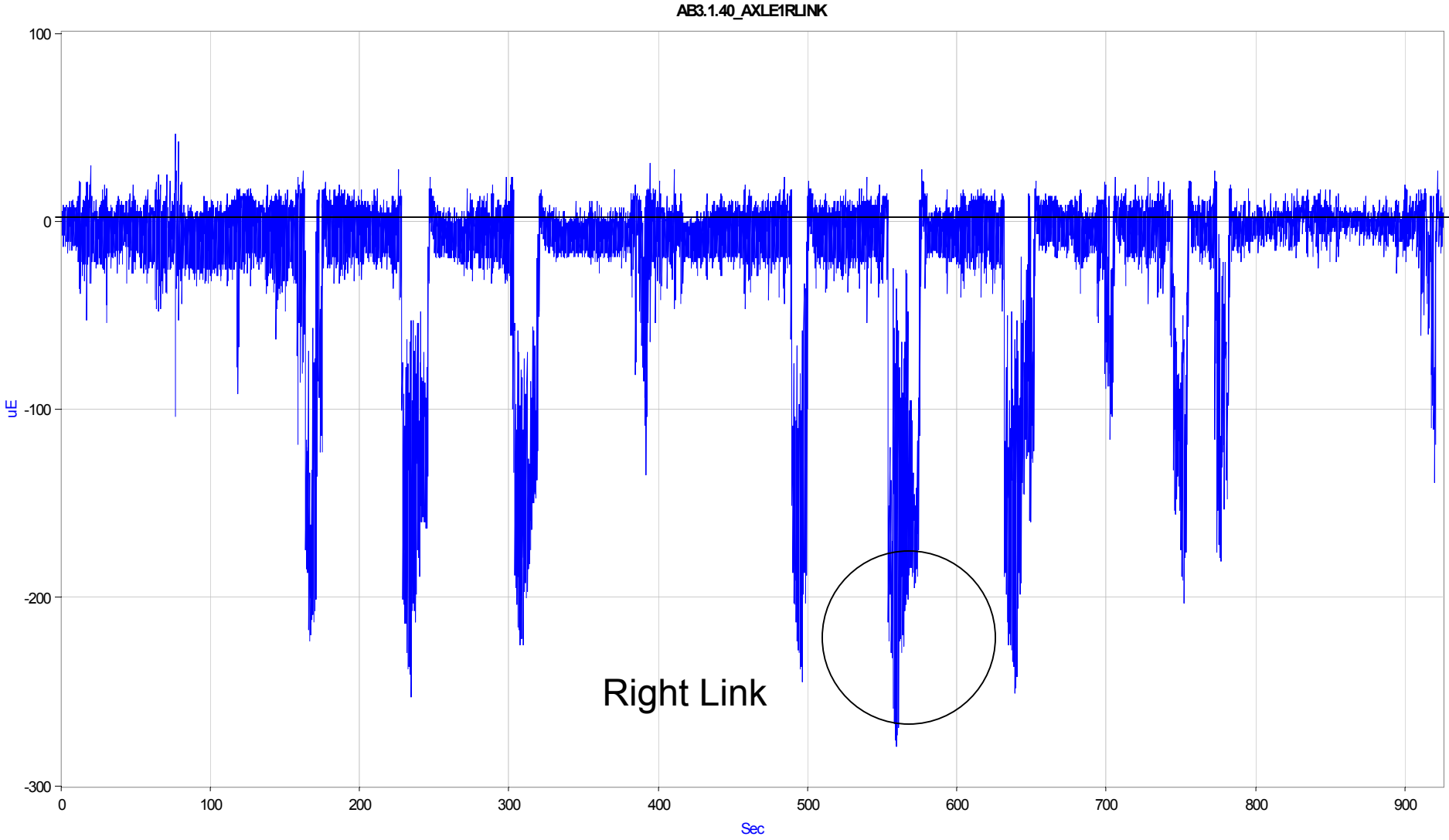
June 17 – File 25 -559 seconds
Braking
Sustained Oscillation Instrumented Axle in Lead



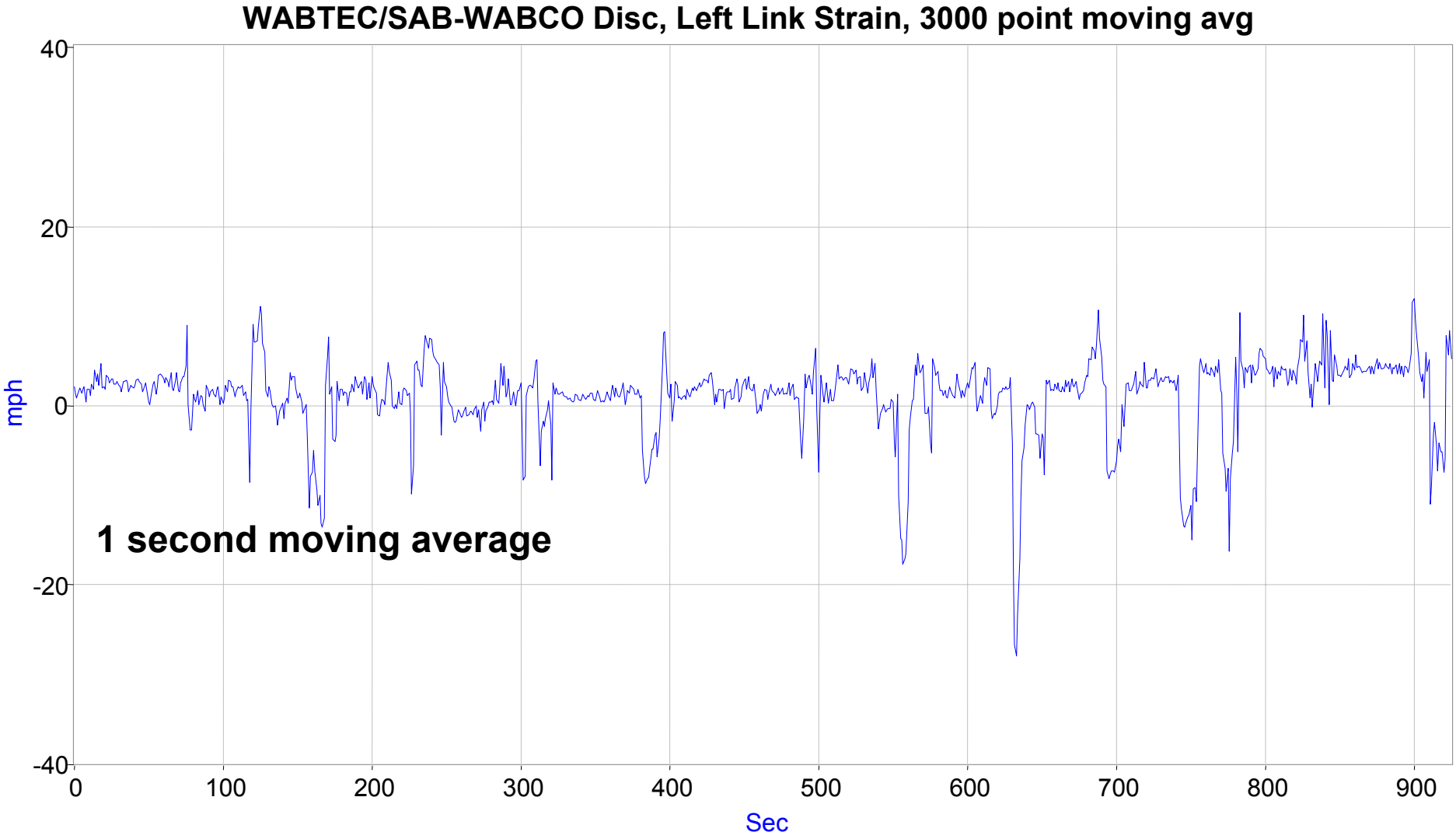
June 17 – File 25 -559 seconds
Braking
Sustained Oscillation Instrumented Axle in Lead



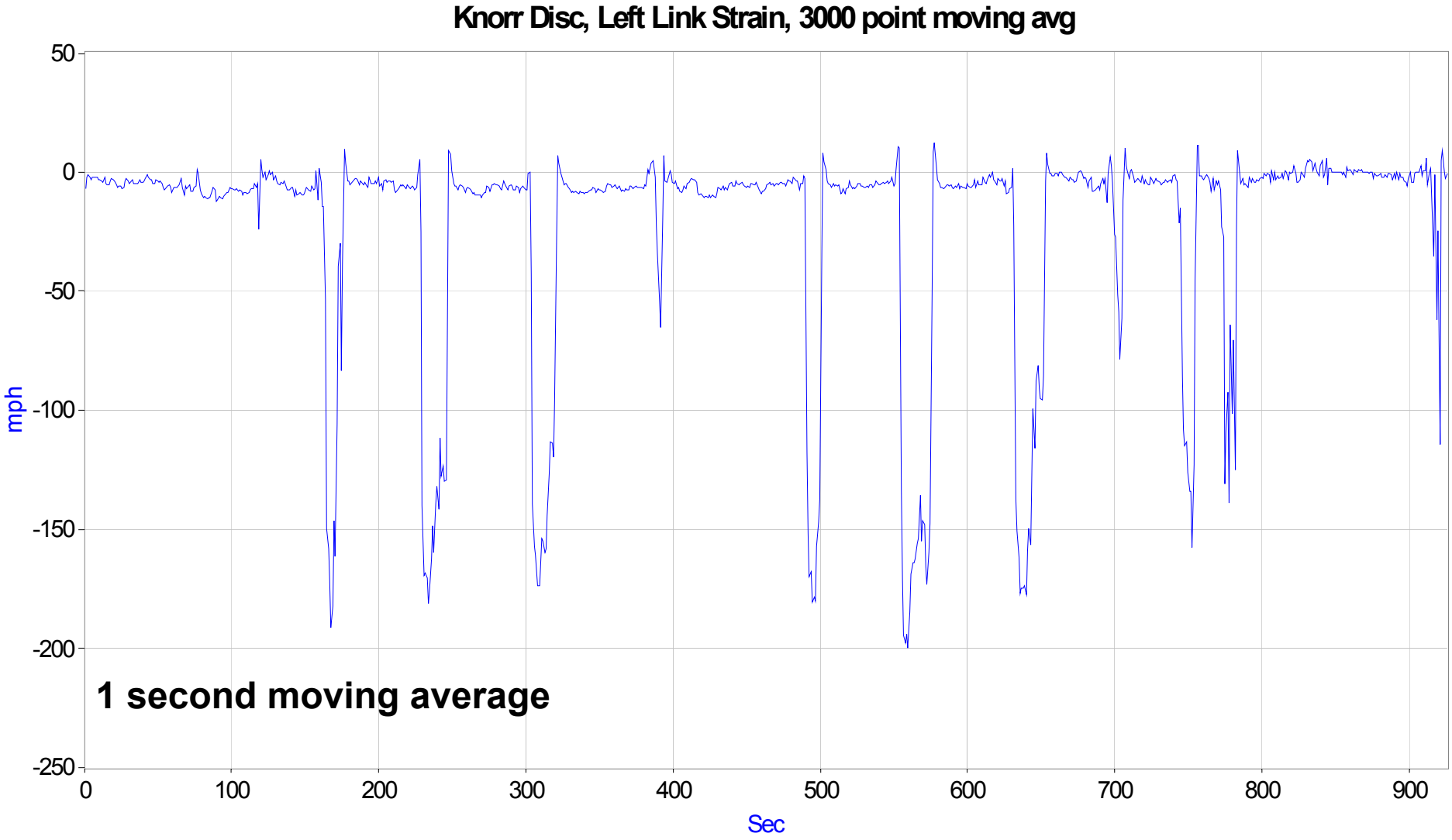
June 17 – File 25 -559 seconds
Braking
Sustained Oscillation Instrumented Axle in Lead



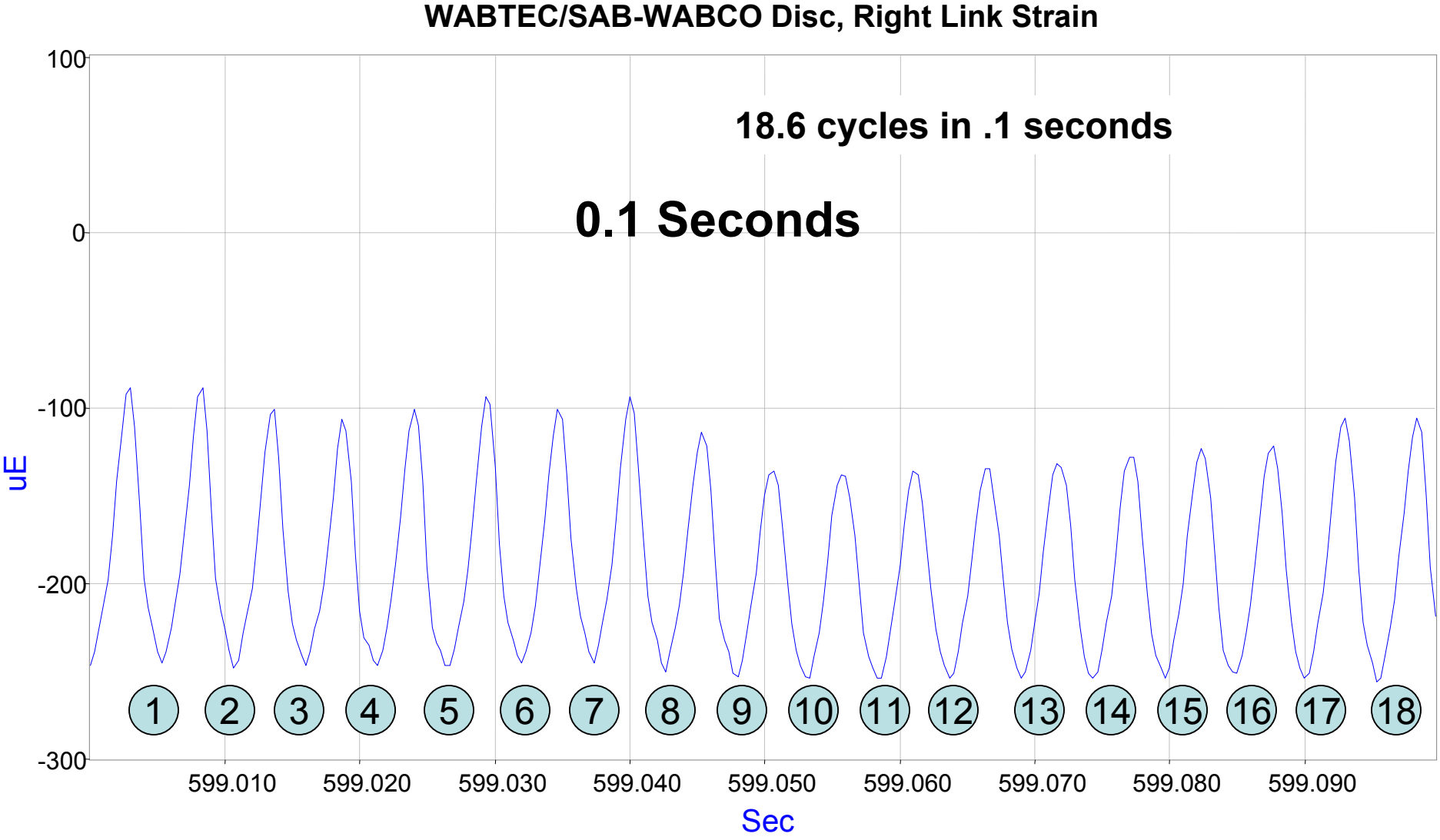
June 17 – File 25 -559 seconds
Braking
Sustained Oscillation Instrumented Axle in Lead



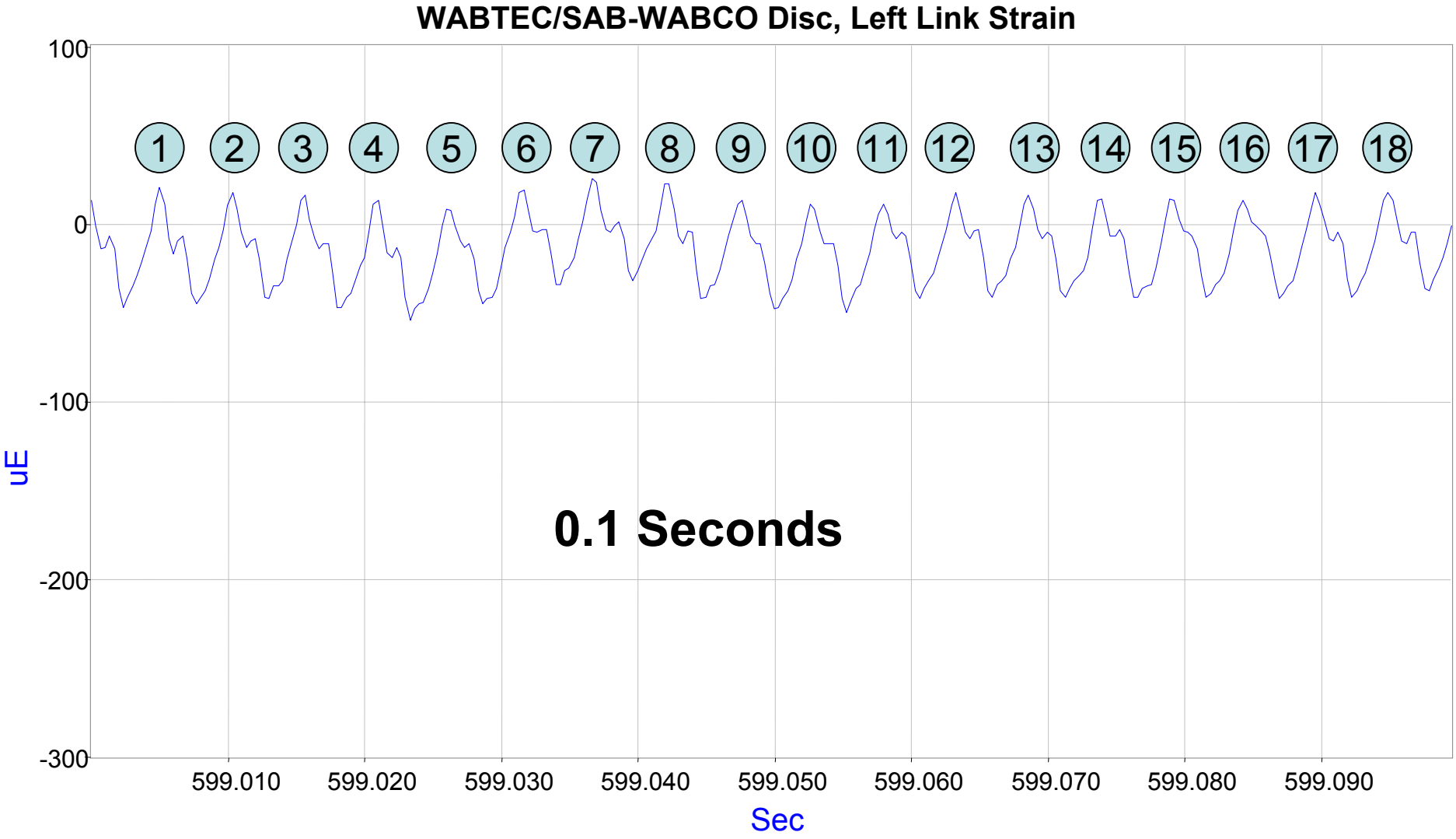
June 17 – File 25 -559 seconds
Braking
Sustained Oscillation Instrumented Axle in Lead



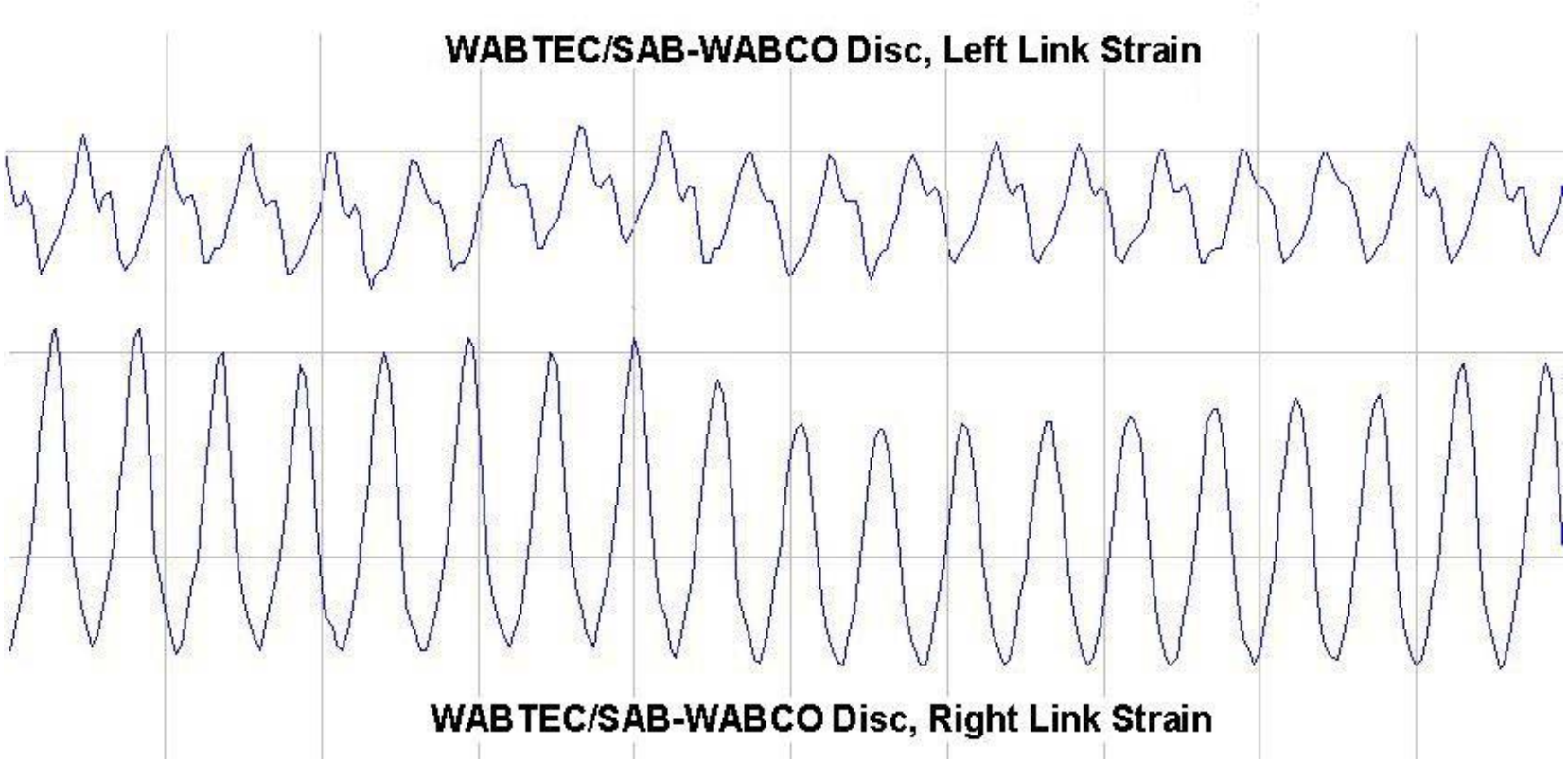
June 17 – File 25 -559 seconds
Braking
Sustained Oscillation Instrumented Axle in Lead



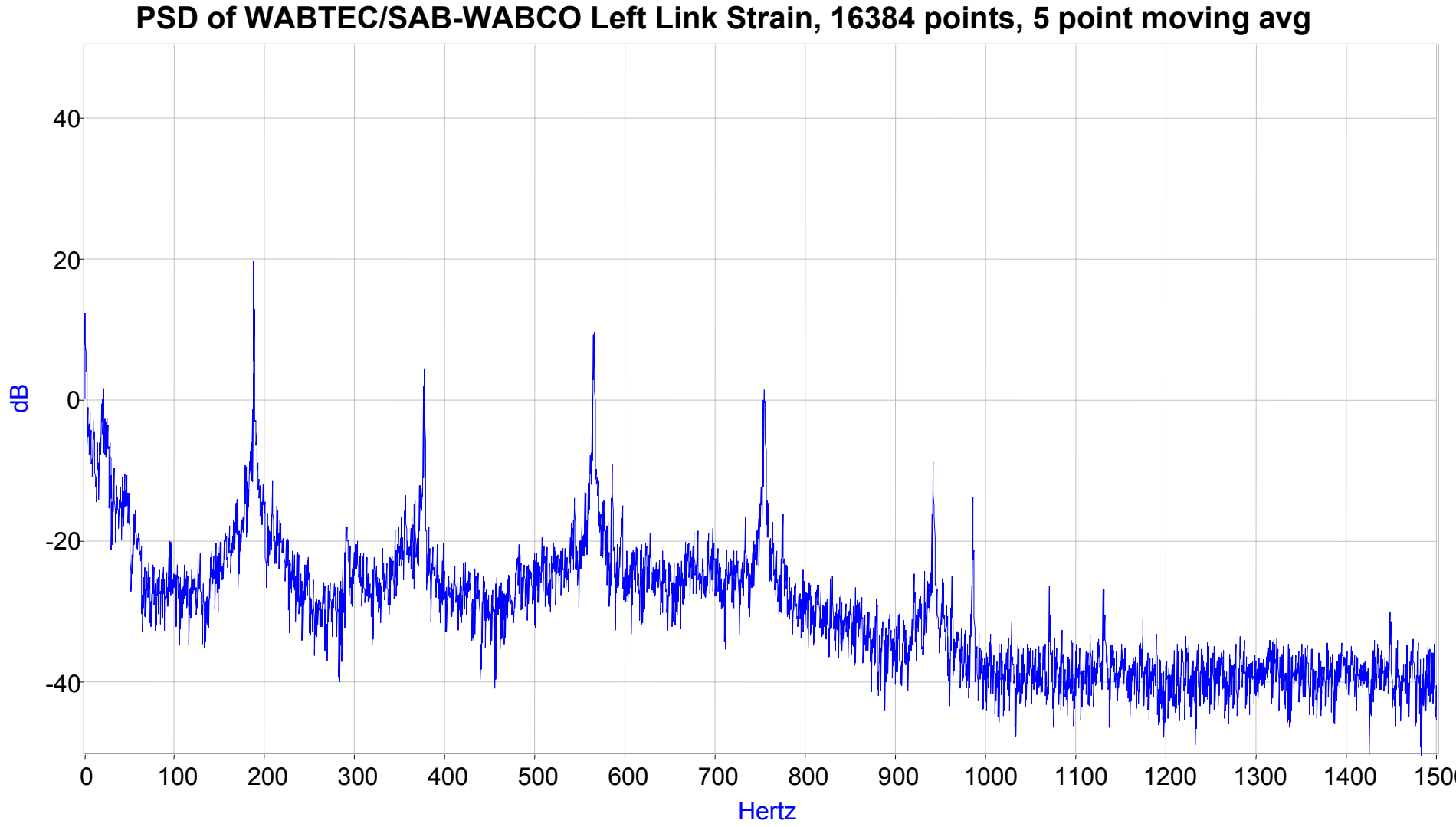
June 17 – File 25 -559 seconds
Braking
Sustained Oscillation Instrumented Axle in Lead



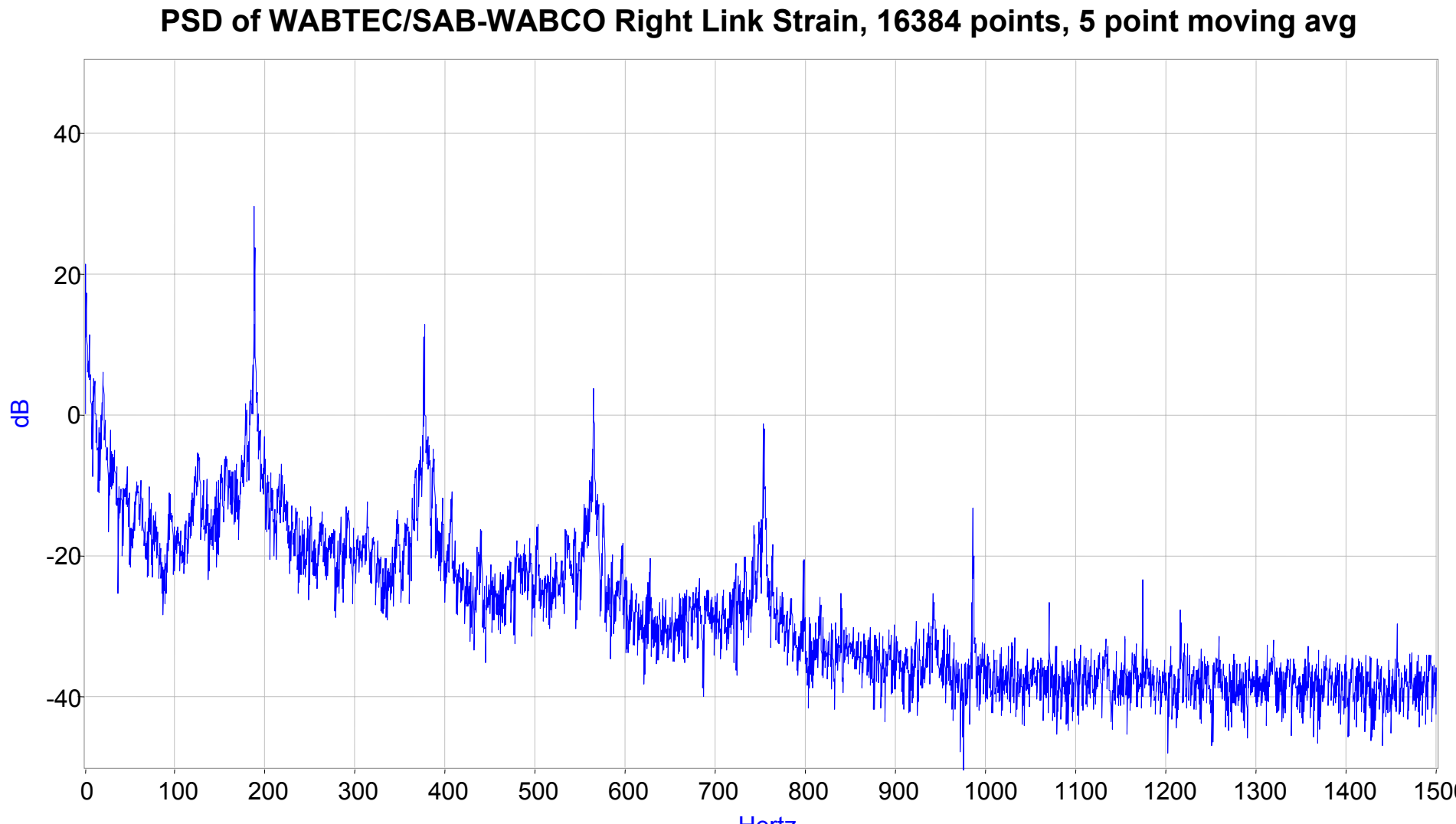
June 17 – File 25 -559 seconds
Braking
Sustained Oscillation Instrumented Axle in Lead
Right and Left Link Out of Phase



June 17 – File 25 -559 seconds
Braking
Sustained Oscillation Instrumented Axle in Lead



June 17 – File 25 -559 seconds
Braking
Sustained Oscillation Instrumented Axle in Lead



June 17 – File 25 -559 seconds
Braking
Sustained Oscillation Instrumented Axle in Lead

Date / File/ time	Sustained Oscillation	Axle	Harmonic Content	Strain Change
June 16 – File 18 -375	No	Trail	No	Tension

Date / File/ time	Sustained Oscillation	Axle	Left Link microstrain	Right Link microstrain
June 17 – File 25 -559	Yes	Lead	-17	-189

Observations

- No sustained oscillations
  - Small Dynamic Link Strains
  - No Harmonic Link Content
  - Brake Links in Compression or Tension
- Sustained Oscillations
  - Only Observed when Brake Links in Compression
  - Large Dynamic Link Strains
  - Harmonic Content – Fundamental Frequency

    ~ 187 Hz
  - May Indicate Stick- Slip Behavior

Observations

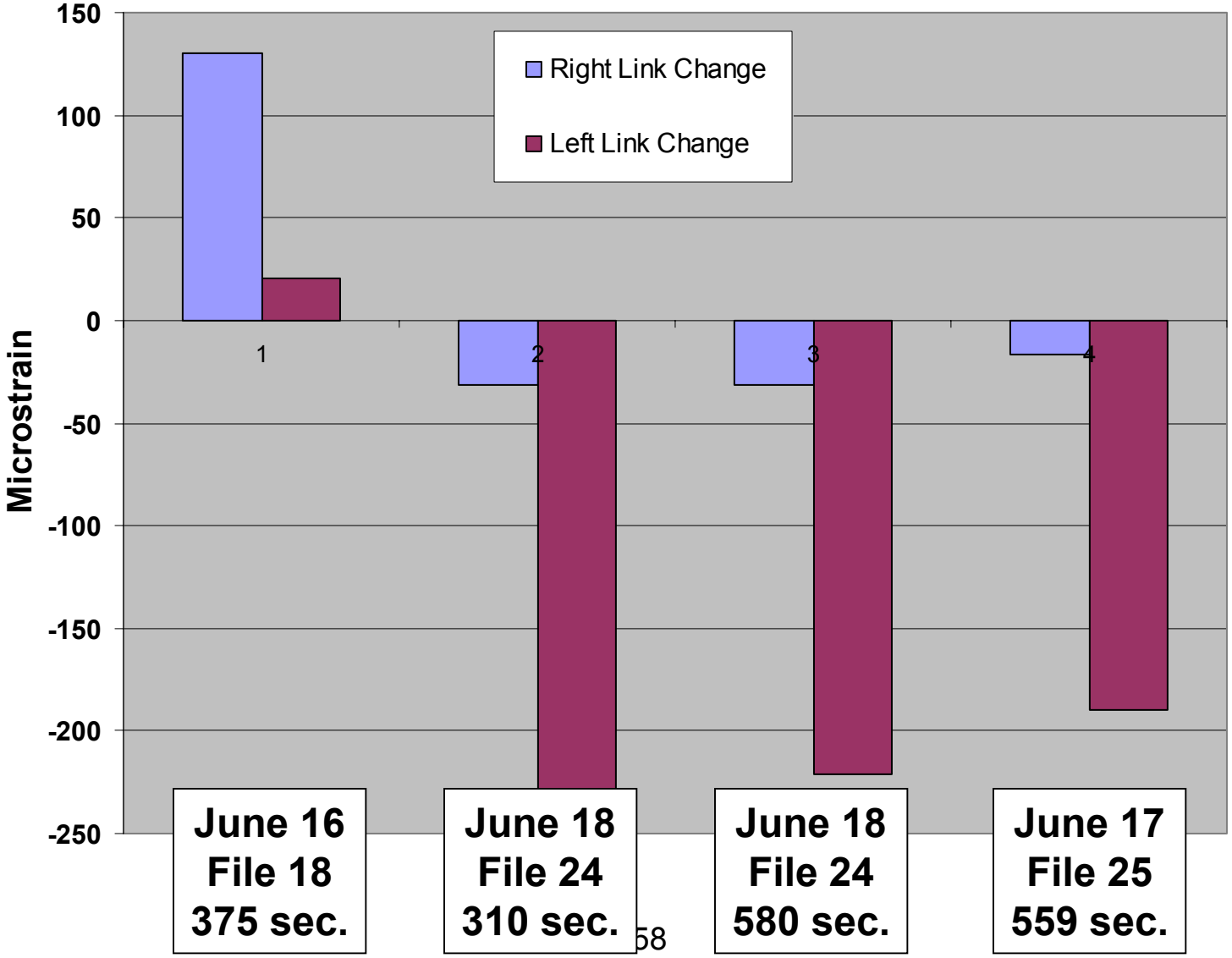
- The Two Links Show Some Similar Behaviors
  - Both Demonstrate Same Direction Of Strain Change
  - Both Have Similar Shape In The Time Domain
- Left Link
  - Larger Than Right Link For Tension (Trailing Axle) By Factor Of 6
- Right Link
  - Larger Than Left Link For Compression (Leading Axle) By Factor Of 7 To 10

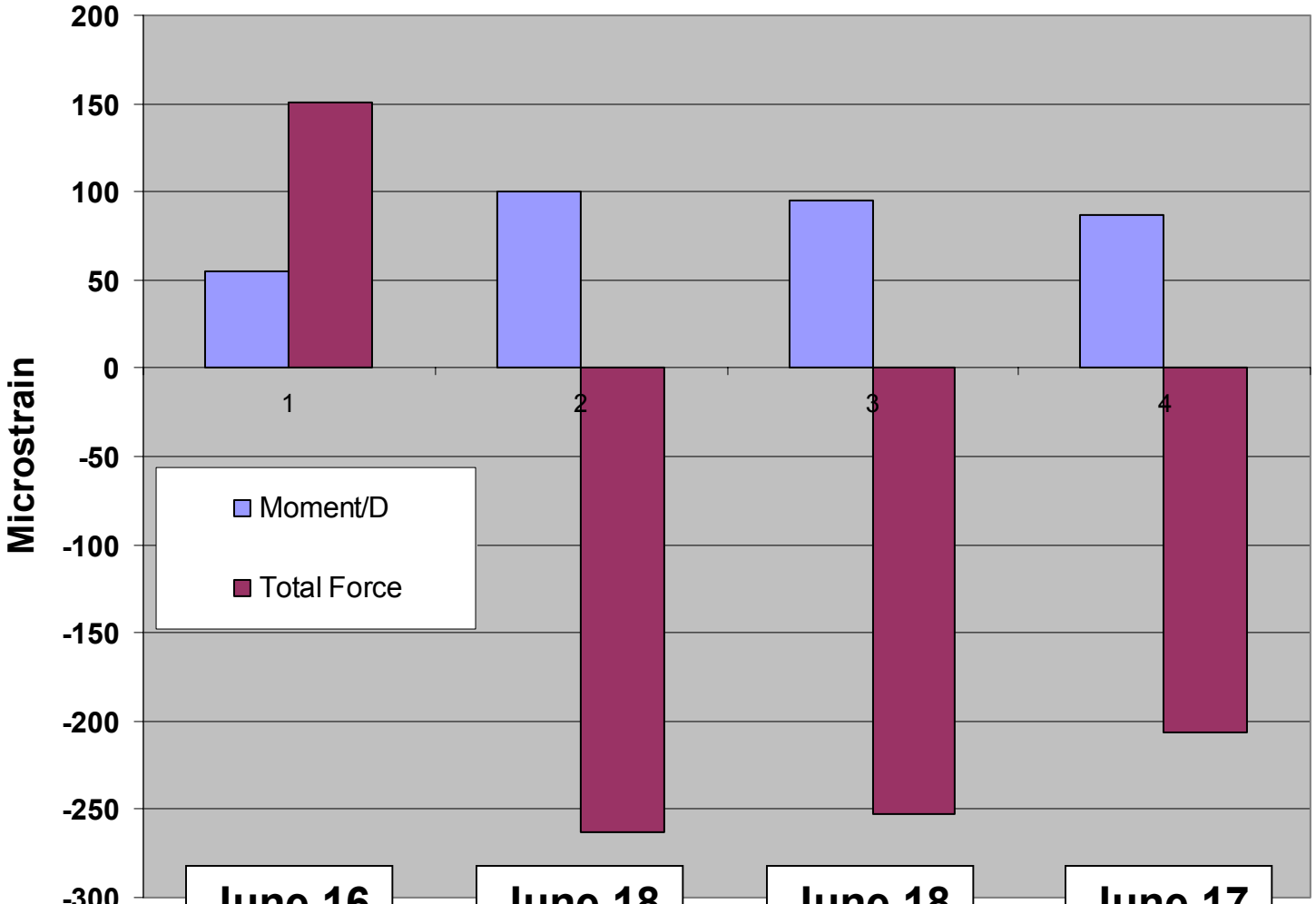
Data Analyzed

Date / File/ time	Sustained Oscillation	Axle	Harmonic Content	Strain Change
June 16 – File 18 -375	No	Trail	No	Tension
June 18 – File 24 - 310	No	Lead	No	Compression
June 18 – File 24 -580	Yes	Lead	Yes	Compression
June 17 – File 25 -559	Yes	Lead	Yes	Compression

Data Analyzed

Date / File/ time	Sustained Oscillation	Axle	Left Link microstrain	Right Link microstrain
June 16 – File 18 -375	No	Trail	+130	+21
June 18 – File 24 - 310	No	Lead	-32	-231
June 18 – File 24 -580	Yes	Lead	-32	-221
June 17 – File 25 -559	Yes	Lead	-17	-189


150
100
50
0
-50
-100
-150
-200
-250
Microstrain
Right Link Change
Left Link Change
1
2
3
4
June 16
File 18
375 sec.
June 18
File 24
310 sec.
June 18
File 24
580 sec.
June 17
File 25
559 sec.


Microstrain
200
150
100
50
0
-50
-100
-150
-200
-250
-300
1
2
3
4
Moment/D
Total Force
June 16
File 18
375 sec.
June 18
File 24
310 sec.
June 18
File 24
580 sec.
June 17
File 25
559 sec.