RAIL TRANSIT SEMINAR

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Cleveland RTA's Red Line: Impact of Rail Grinding on Wheel Life after 18 months

Loram LRG24 16-stone grinder

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Outline

1) **Grinding campaign on the Greater Cleveland RTA Red Line**
   - The Red Line had not been ground…ever
   - The Red Line fleet had a short wheel life
2) **Grinding results**
   - Did the new rail profiles have an impact on wheel life?
3) **Rail grinding QC - what measurements make sense?**

1) Grinding campaign on GCRTA's Red Line

One reason for grinding: Excessive wheel tread wear

- Historical monthly tread wear is 0.15" diameter (or 0.075" tread, roughly 1/16") from a combination of wear and wheel truing.
- Flange wear is not an issue
- RTA's standard 28-inch wheel reaches its replacement limit at 26 inches (2" dia. wear / 1" tread wear)
- Avg wear: 2" / 0.15"/month = 13 months
- Typical vehicle travels 6000 miles/month
- Avg wheel life 13 months x 6000 miles = 78,000 miles

Hollow-worn wheels in the recycling dumpster

Another example of a worn wheel

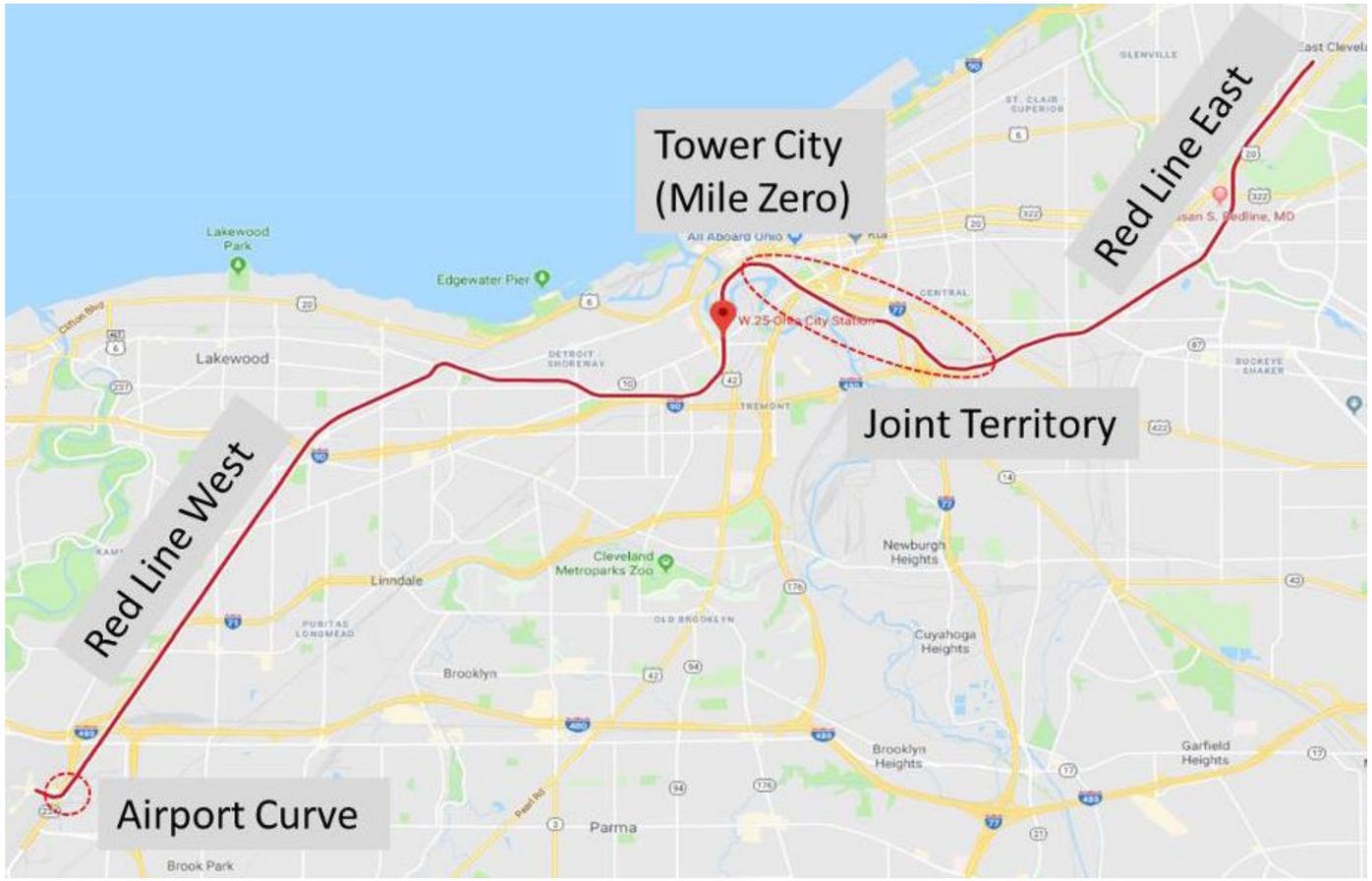
Virtually no flange wear on either the front or back sides

Likely reasons:

a) Very effective lubrication program

b) Restraining rails on curves ≥ 6°

Greater Cleveland RTA Red Line



- Lines east from Tower City to Windemere, 8 route miles
- Lines west from Tower City to Cleveland airport, 11 route miles
- All double track
- 60% tangent track
- Curves over 6 degrees have restraining rails
- Maximum speed 60 mph

Loram's LRG24 grinder

- 1 power car
- 2 grinding cars, each with 8 stones (16 total)
- KLD rail profile measurement system

Video 1 — Loram's LRG24 grinder

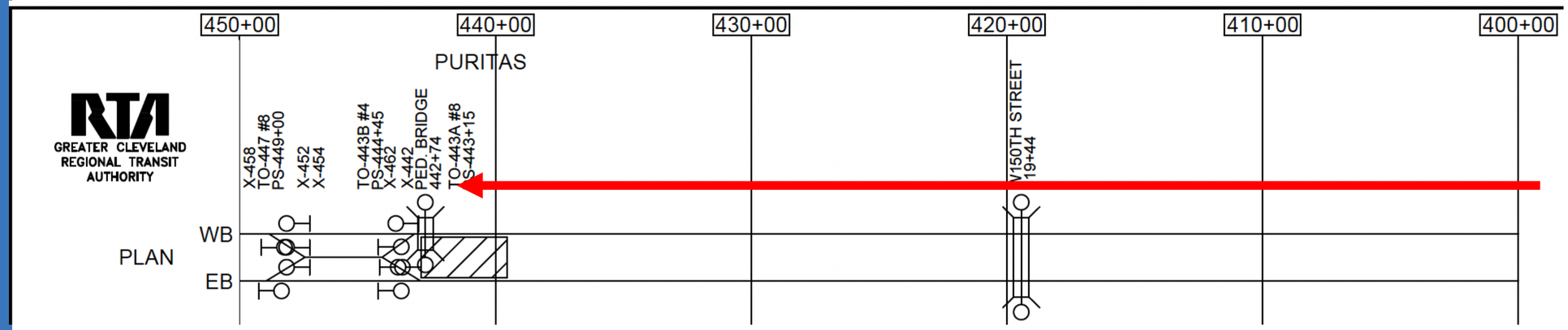
Red Line grinding production results

LRG24 production results	
Grind shifts	28
Dates, from - to	Aug 3 - Sept 22, 2023
Average track time / shift	6.9 hours
Average spark time / shift	4.1 hours
Total pass distance	506 miles
Total completed distance	35.3 miles

Key to productivity was RTA's decision to operate revenue trains around the grinder (on single track) from 7:00 pm to 1:00 am.

Those six hours, plus two hours of "after service" time, from 1:00 am to 3:00 am, gave the grinder 8 hours of track time.

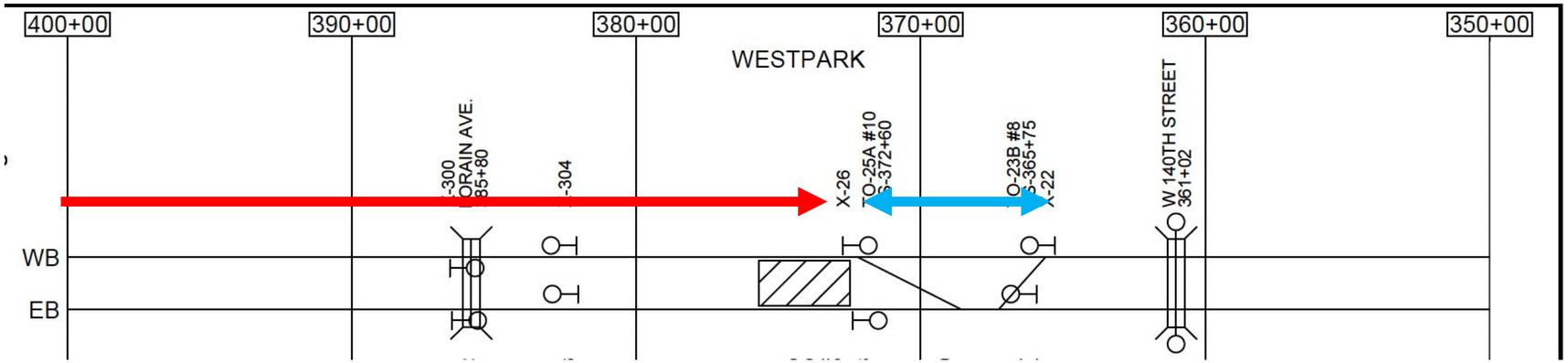
RTA's track time strategy



Typical passes

Tangents – 15

Curves - 25



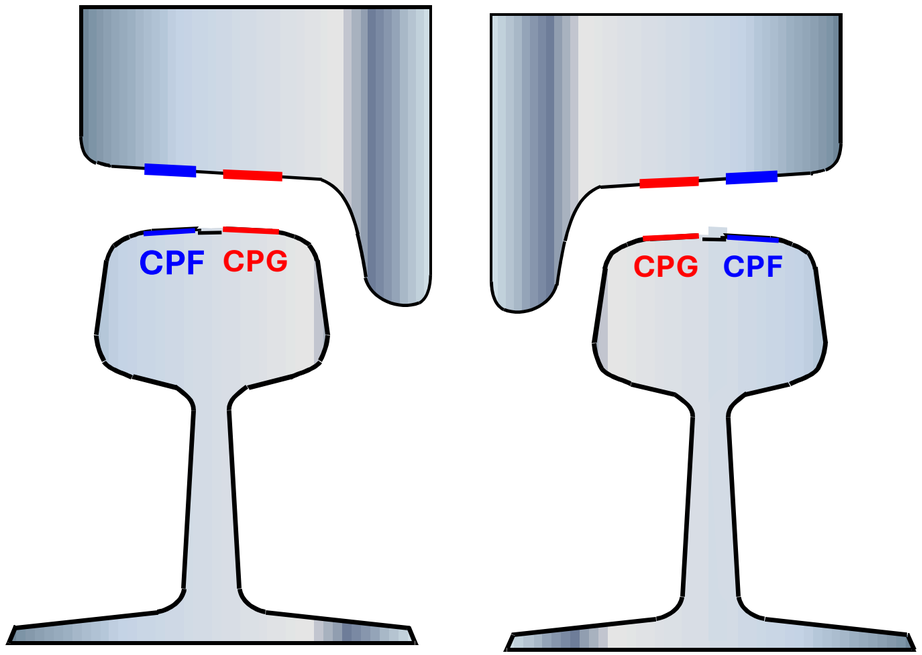
RTA gave the grinder one block each day during service hours (7 pm – 1 am).
Red Line trains ran around on the adjacent track.

During after-service hours the grinder worked through an interlocking.

New rail profiles

National Research Council of Canada (NRC) developed two tangent profiles:

- Contact point gage (CPG)
- Contact point field (CPF)



And two curve profiles:

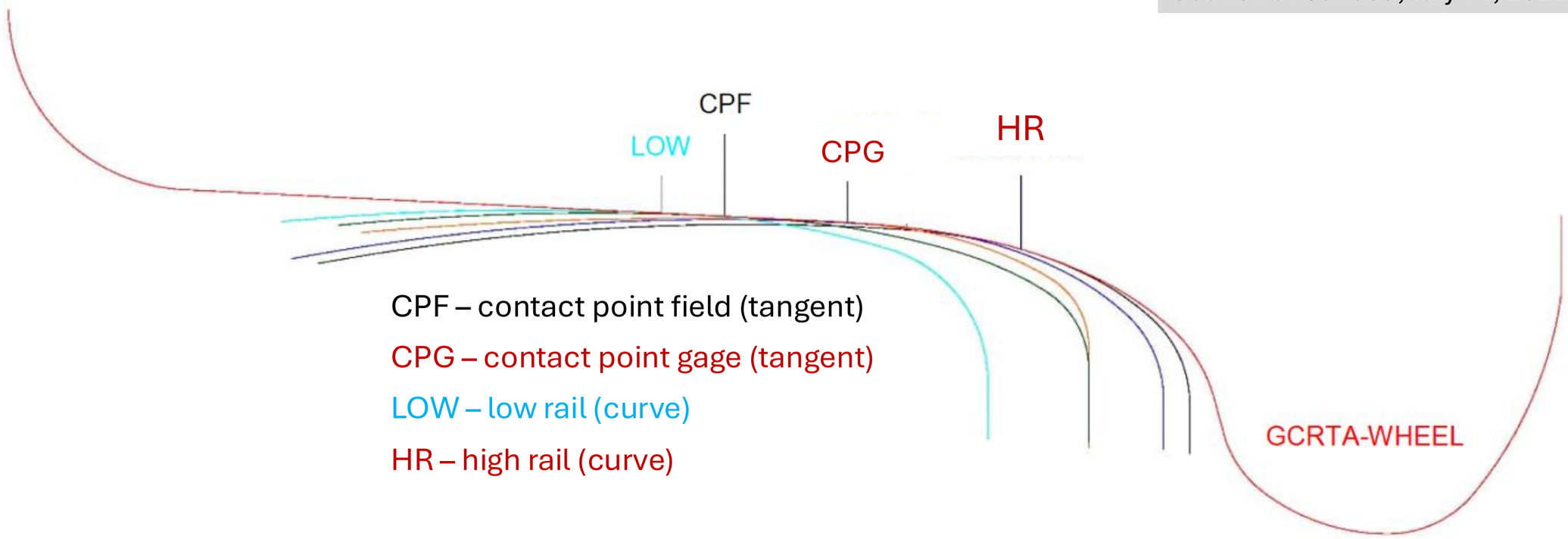
- Curve low rail (LOW)
- Curve high rail (HR)

Strategy behind these profiles:

1. On tangents, the CPF was applied to the Eastbound and the CPG to the Westbound. Objective: distribute rail contact over a wider part of the tread.
2. On curves, the low- and high-rail profiles take advantage of rolling radius differential to improve wheelset steering.

Rail profile design strategy

Image & text: Rob Caldwell, GCRTA Wheel/Rail Study, National Research Council of Canada, July 11, 2022



CPF – contact point field (tangent)

CPG – contact point gage (tangent)

LOW – low rail (curve)

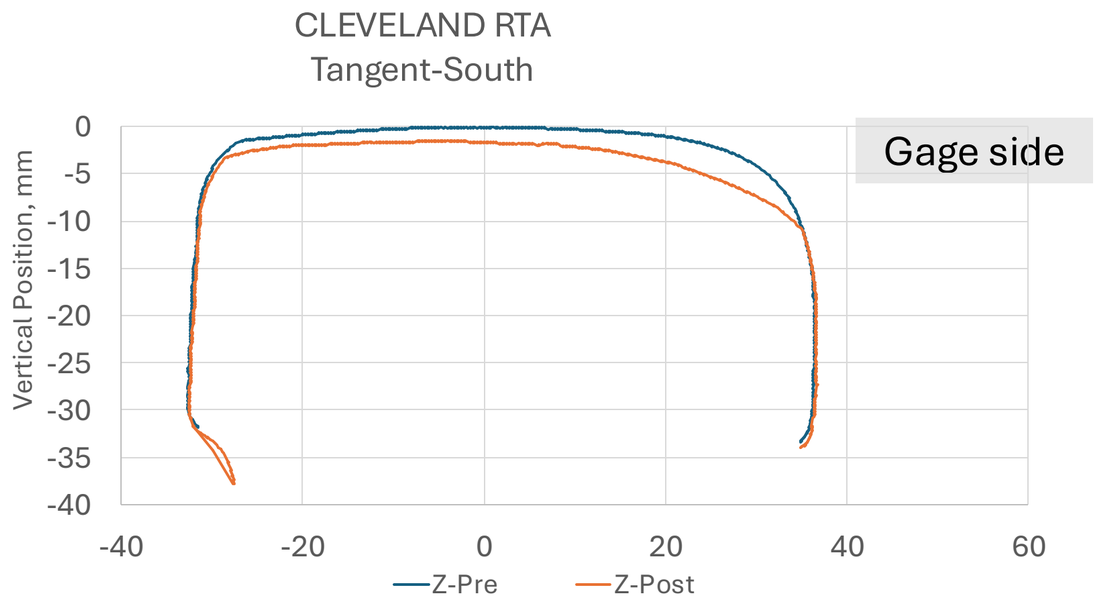
HR – high rail (curve)

- Track people are accustomed to looking at how wheel contact moves across the rail. Here, it's the reverse: look at how the rail moves across the wheel tread.
- Contact is shown for standard track gage. Variations in track gage will further distribute wear across both the wheel tread and rail head.

Videos illustrating the various rail profiles

- GoPro camera mounted on axle 4 of car 336, using brackets made by RTA and attached using existing holes on the back of the truck
- Coming up: 15-second video clips showing pre-grind rail and the four design profiles: CPF, CPG, HR & LOW

Rail profiles - pre-grind wheel contact on tangent

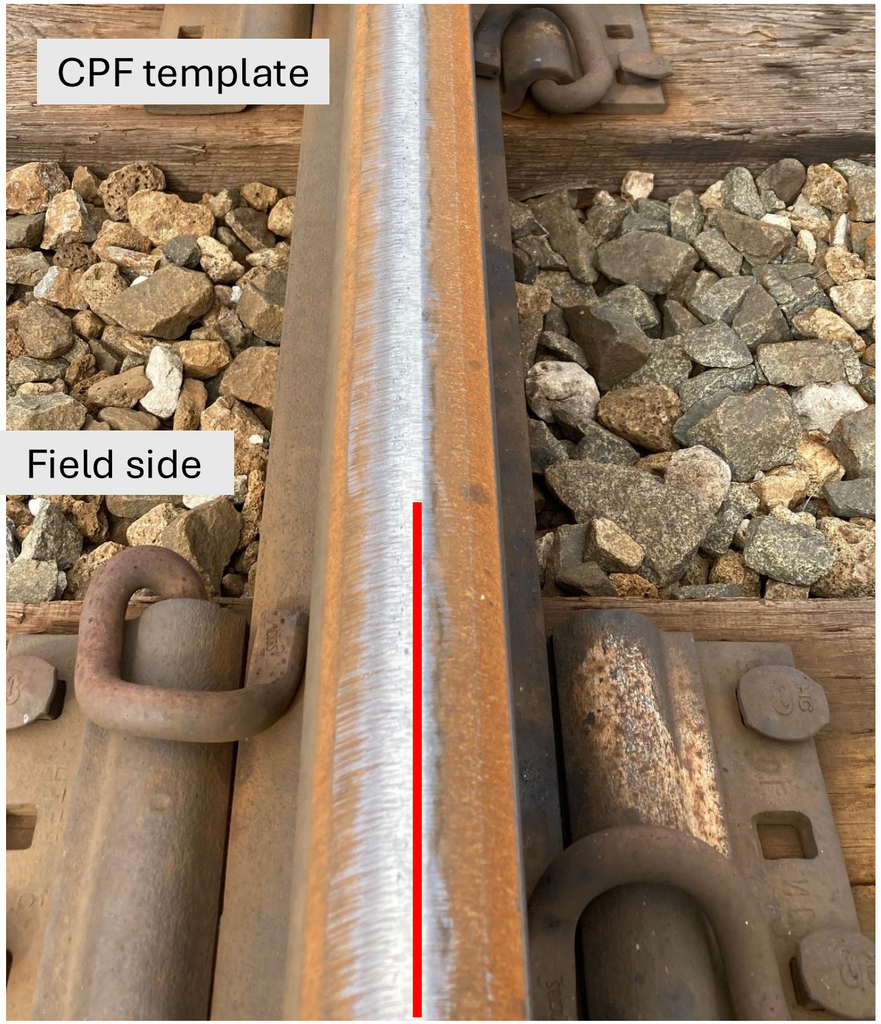


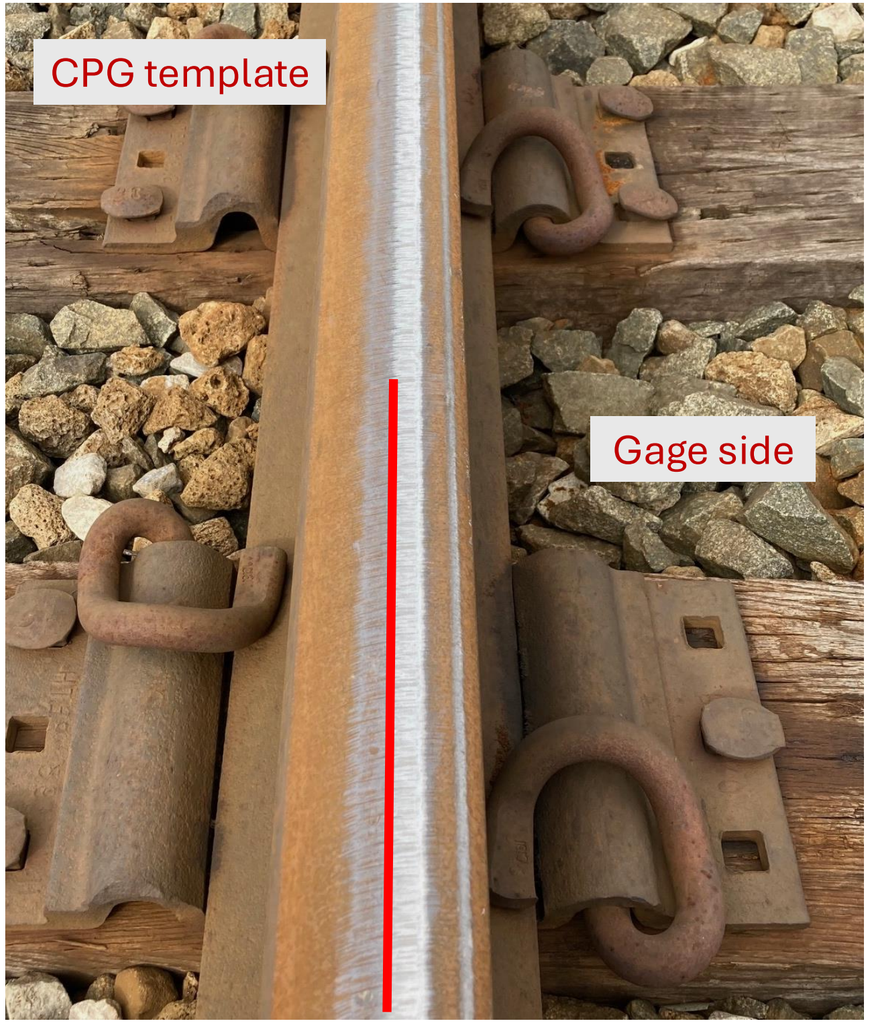
MiniProf pre-grind profile (blue). The flat profile means small variations in wheel shape result in a wide range of rail contact locations. Shown with a post-grind **CPF profile** (red).

Pre-grind wheel contact band covers the entire head.

Video 2 — APTA 220 wheel on pre-grind rail on tangent

Rail profiles – CPF & CPG on tangent



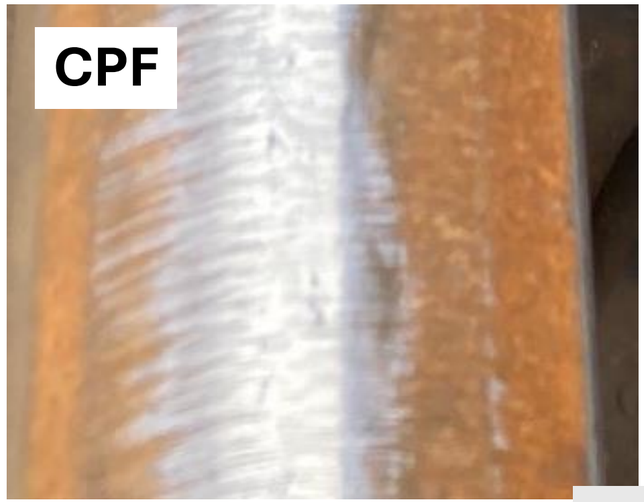


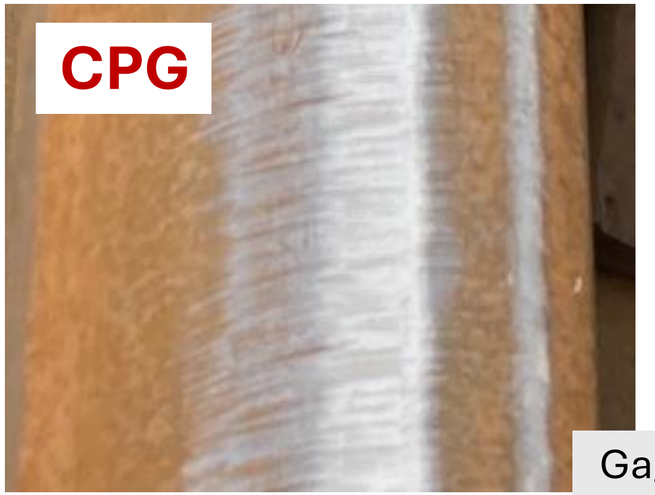
The CPF template was used on the EB track; contact 3/8” to field side of center.

The CPG template was used on the WB track; contact 1/8” to gage side of center.

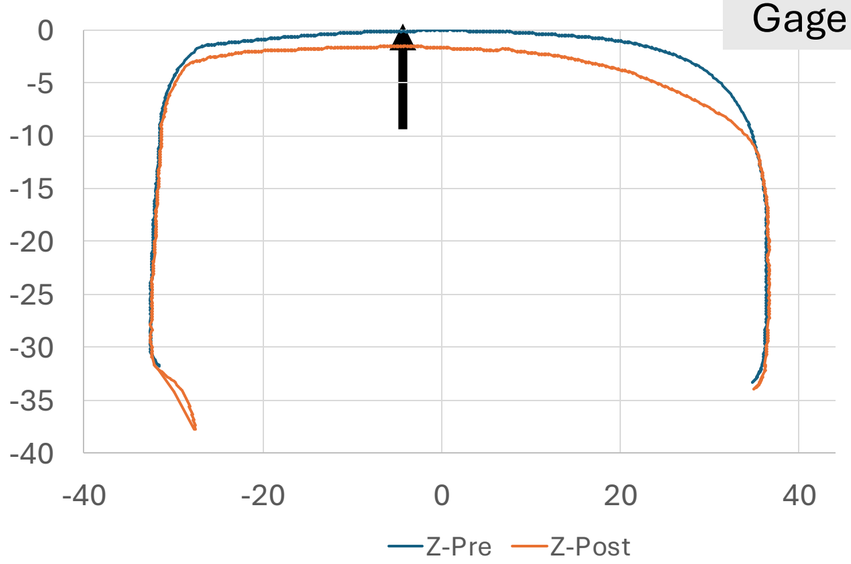
Photos one month after grinding.

MiniProf – tangent pre- & post-grind profiles





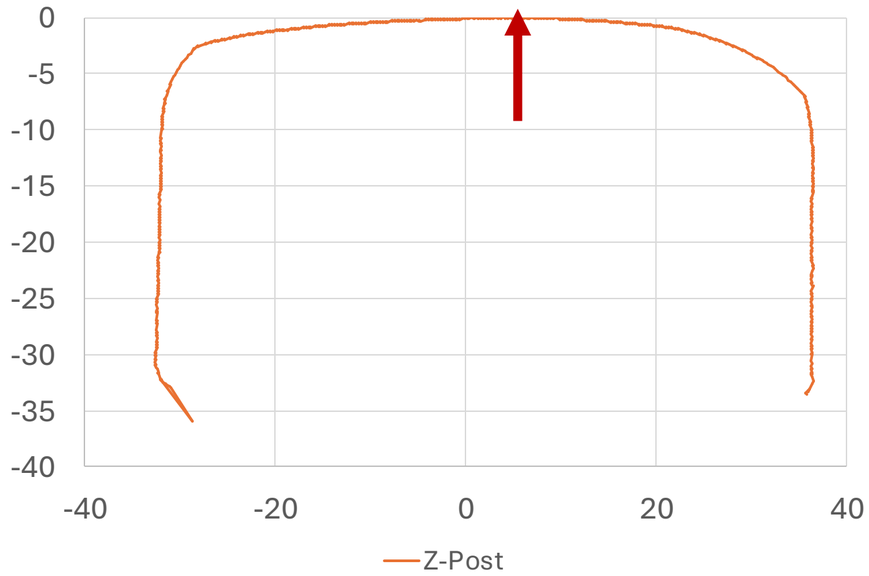
Gage side



Blue profile pre-grind

Red profile post-grind

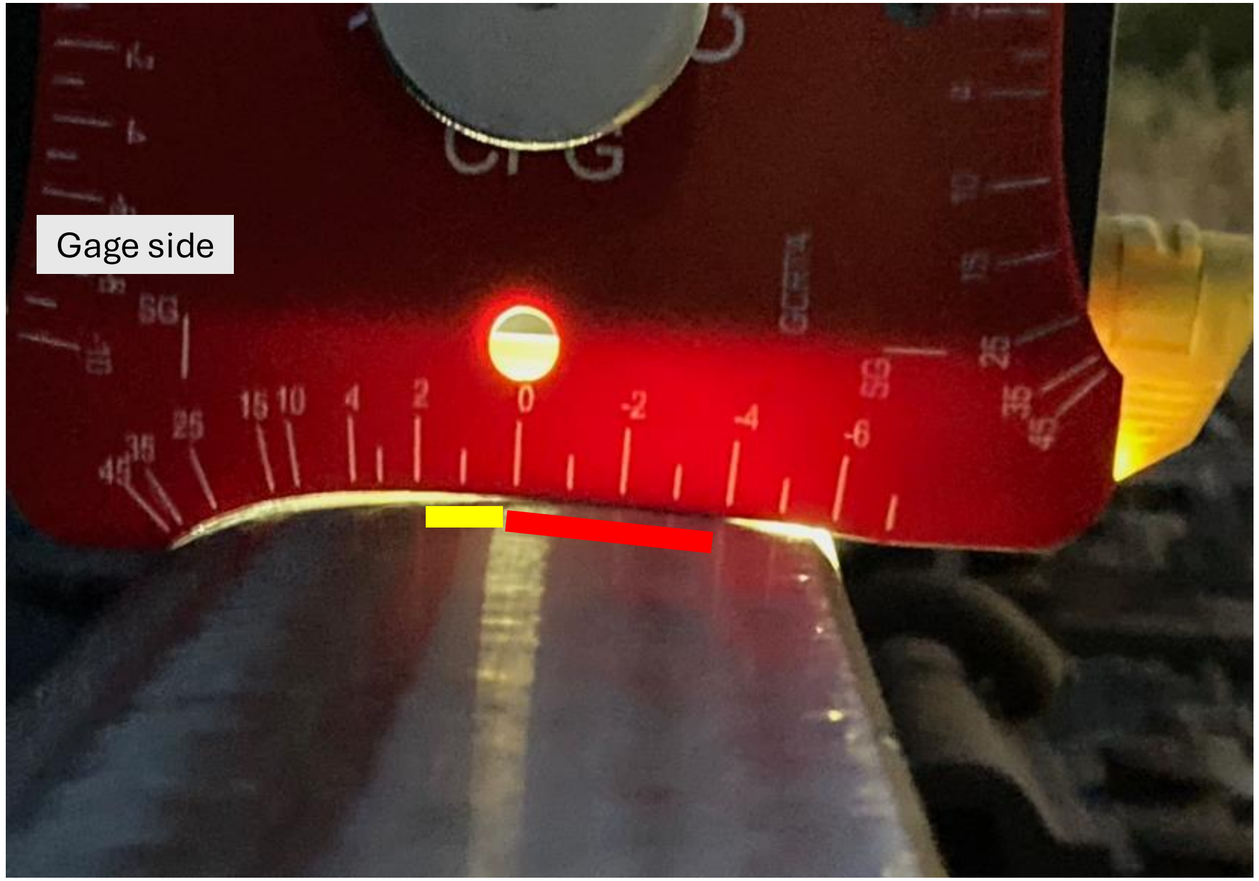
Gage side



EB track, contact centered 3/8” to field side

WB track, contact centered 1/8” to gage side

Grinding a CPG profile



At night, the back light on the bar gage illuminates the gap between the CPG template and the rail.

For the CPG profile, the desired wheel contact location is between 0° and +1° (1/8” on the gage side of center, yellow line).

Despite having a gentle center-high crown radius, additional metal needs to be removed between 0° and -4° (red line) to match the CPG template.

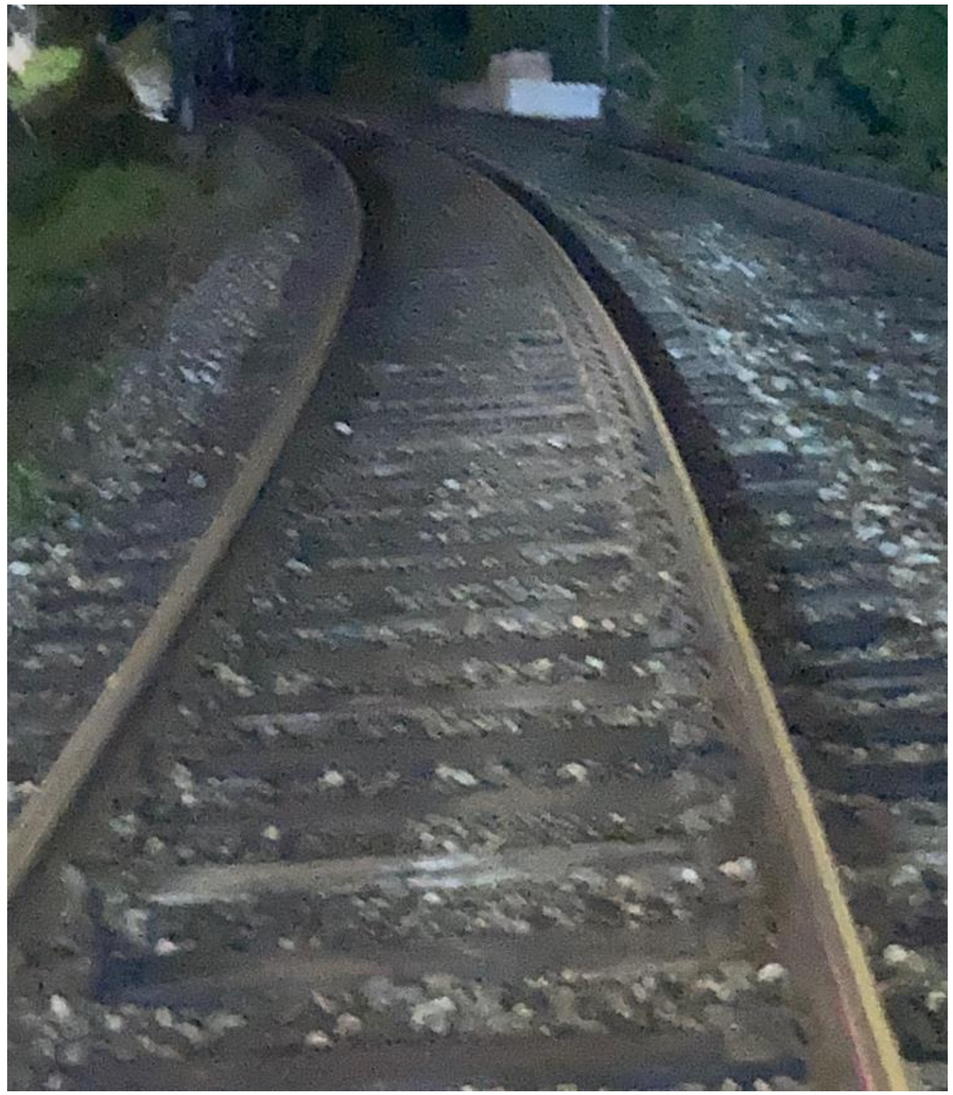
Video 3 — APTA 220 wheel on tangent CPF

Video 4 — APTA 220 wheel on tangent CPG

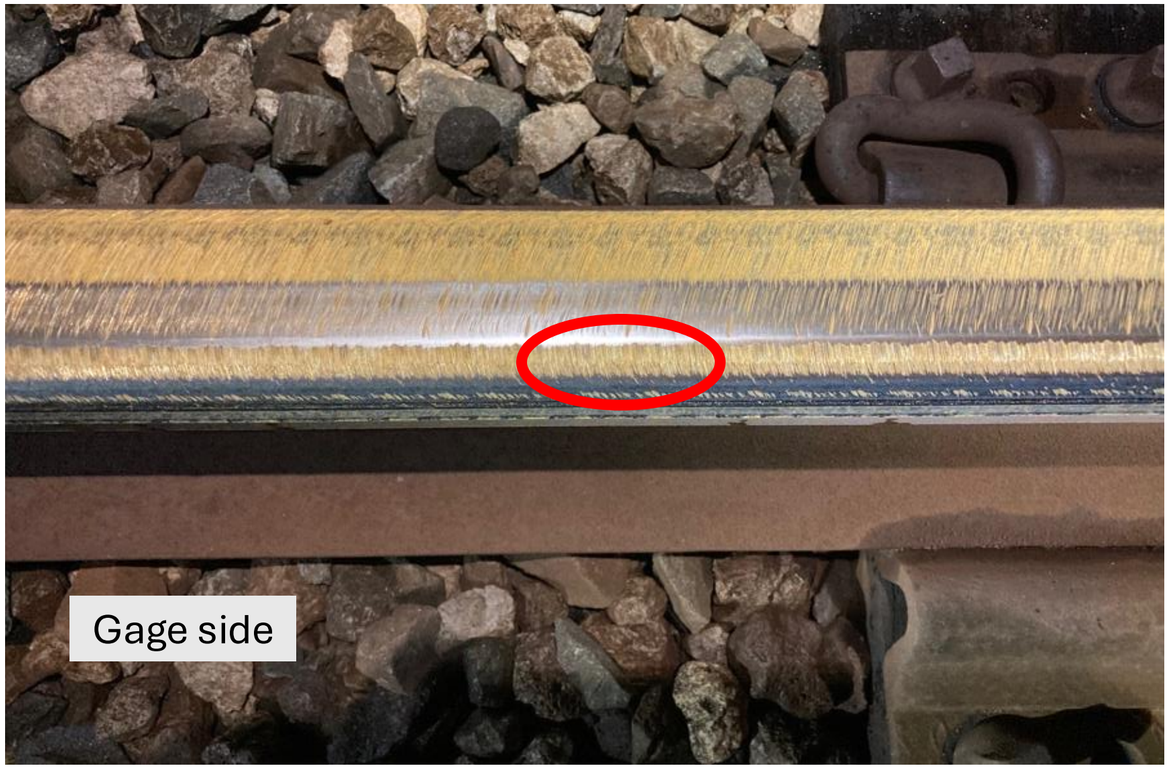
Profiles high and low rails on a curve

Post-grind photos were taken on a 3.8° degree curve

Photos one week after grinding

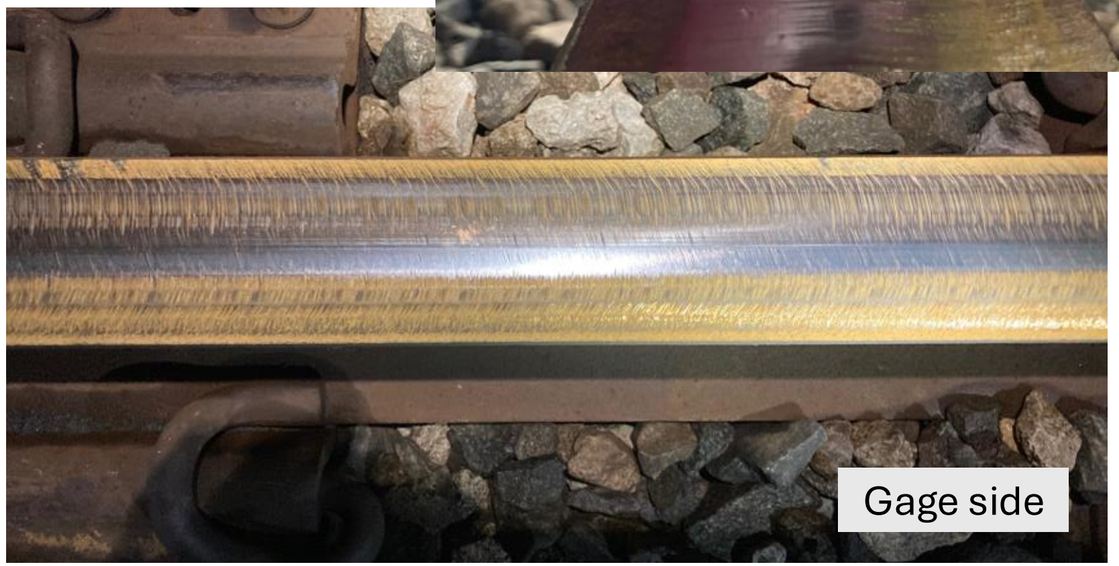


Rail profiles – curve HR



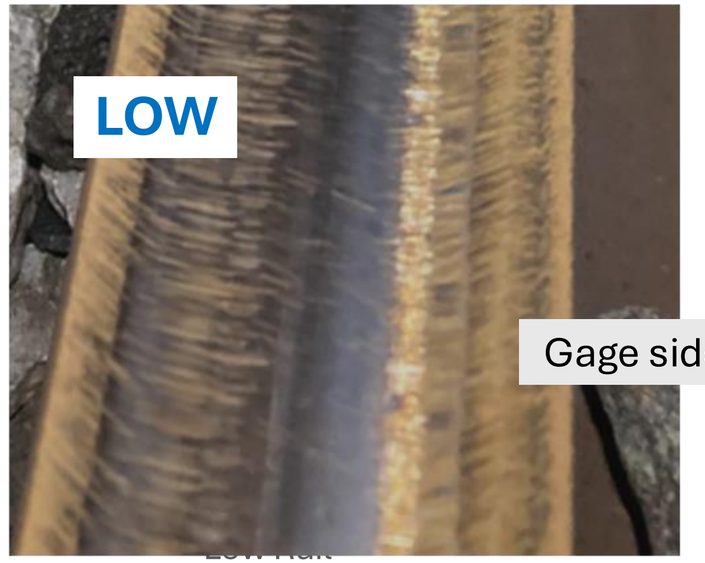
Note 2-point contact – gage-face contact band and a separate tread contact band

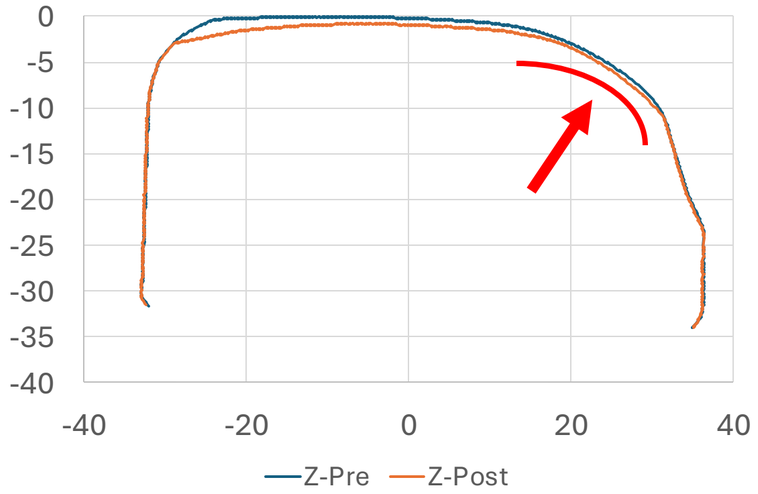
Rail profiles – curve LOW



Primary contact band is centered. The LOW template shows a very good match with the actual rail profile.

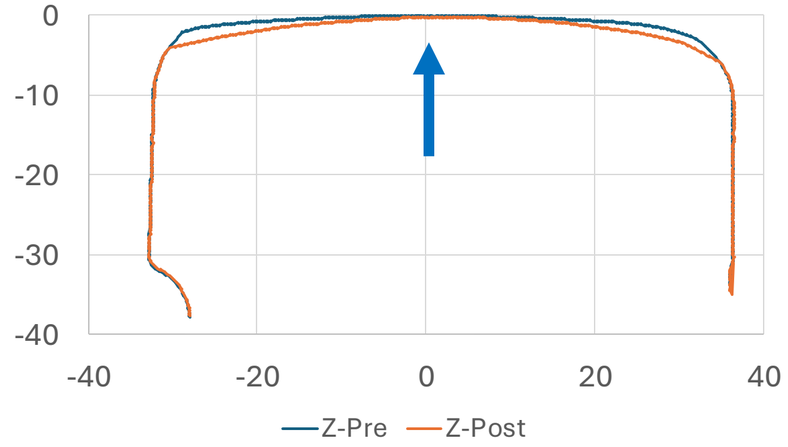
MiniProf - curve pre- & post-grind profiles





Blue profile pre-grind

Red profile post-grind



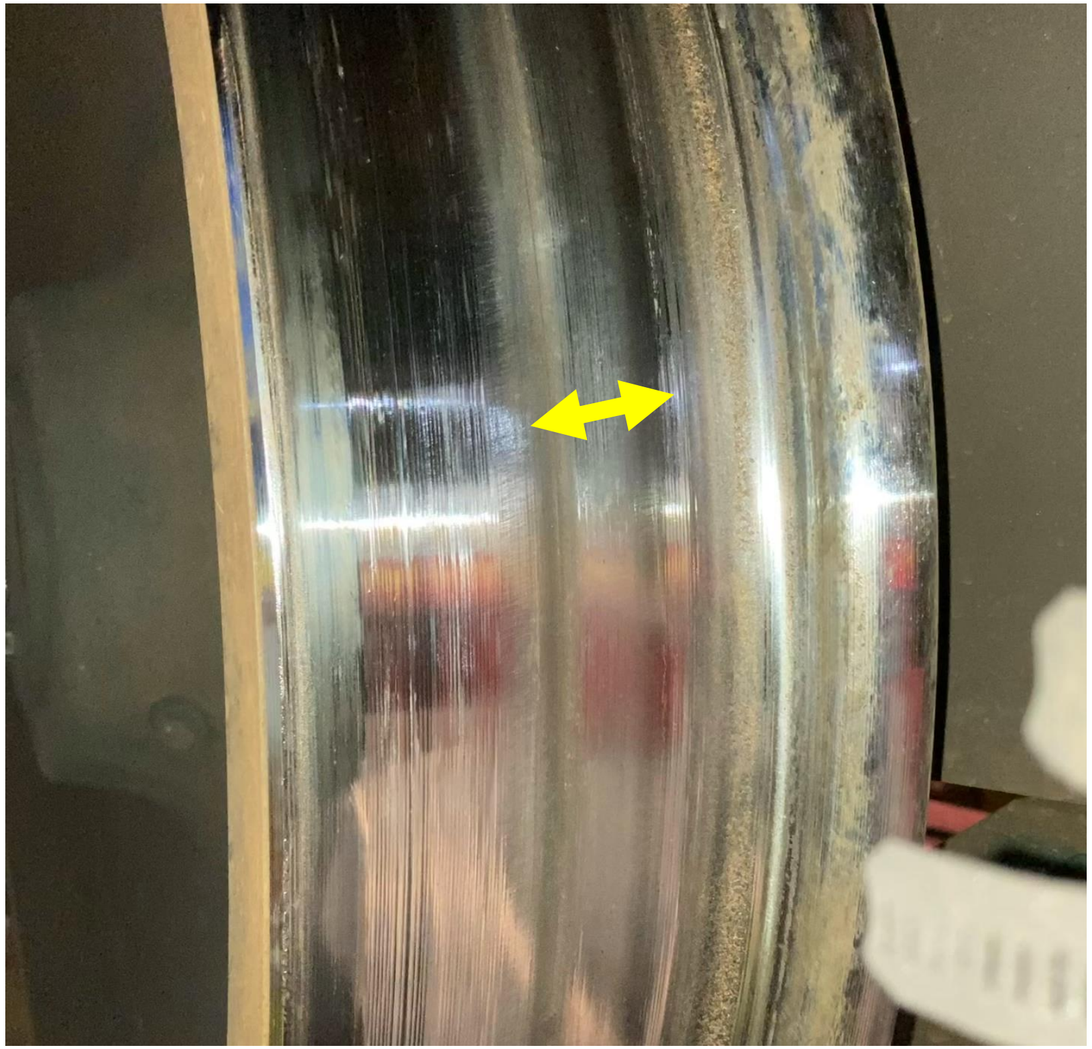
Design conformal contact

Design contact center of rail

Video 5 — APTA 220 wheel on curve HR

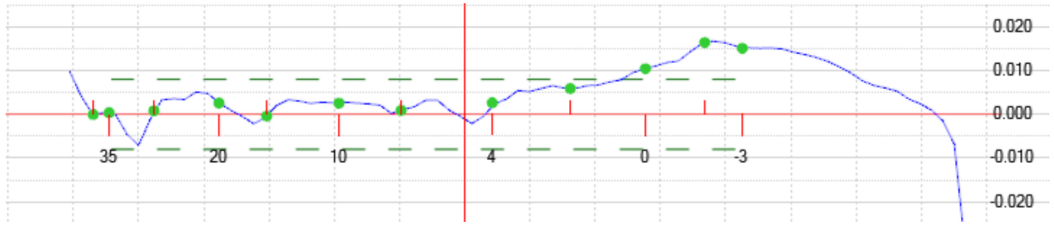
Video 6 — APTA 220 wheel on curve LOW

Contact band on newly-trued APTA 220 wheel



- This is the wheel shown in the wheel/rail videos
- Just off the wheel lathe, the wheel ran 27 miles, mostly on post-ground track
- A 3/4”-wide rail contact band is evident

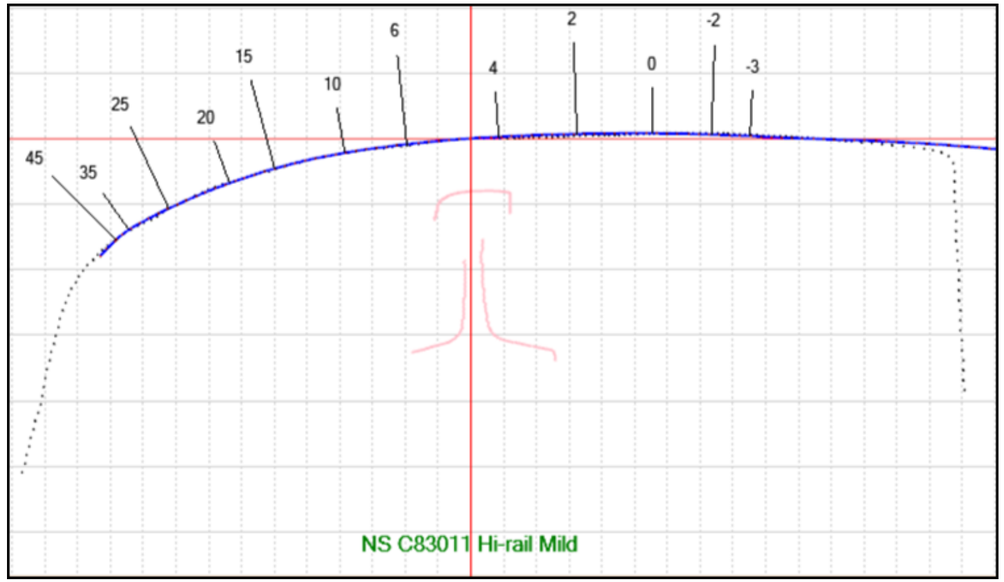
Grind quality assessment using GQI



We did calculate GQI, using post-grind profiles.

We did not find GQI to be useful in assessing the grind quality.

What we did find useful: location of the wheel contact bands and ride quality (hunting).



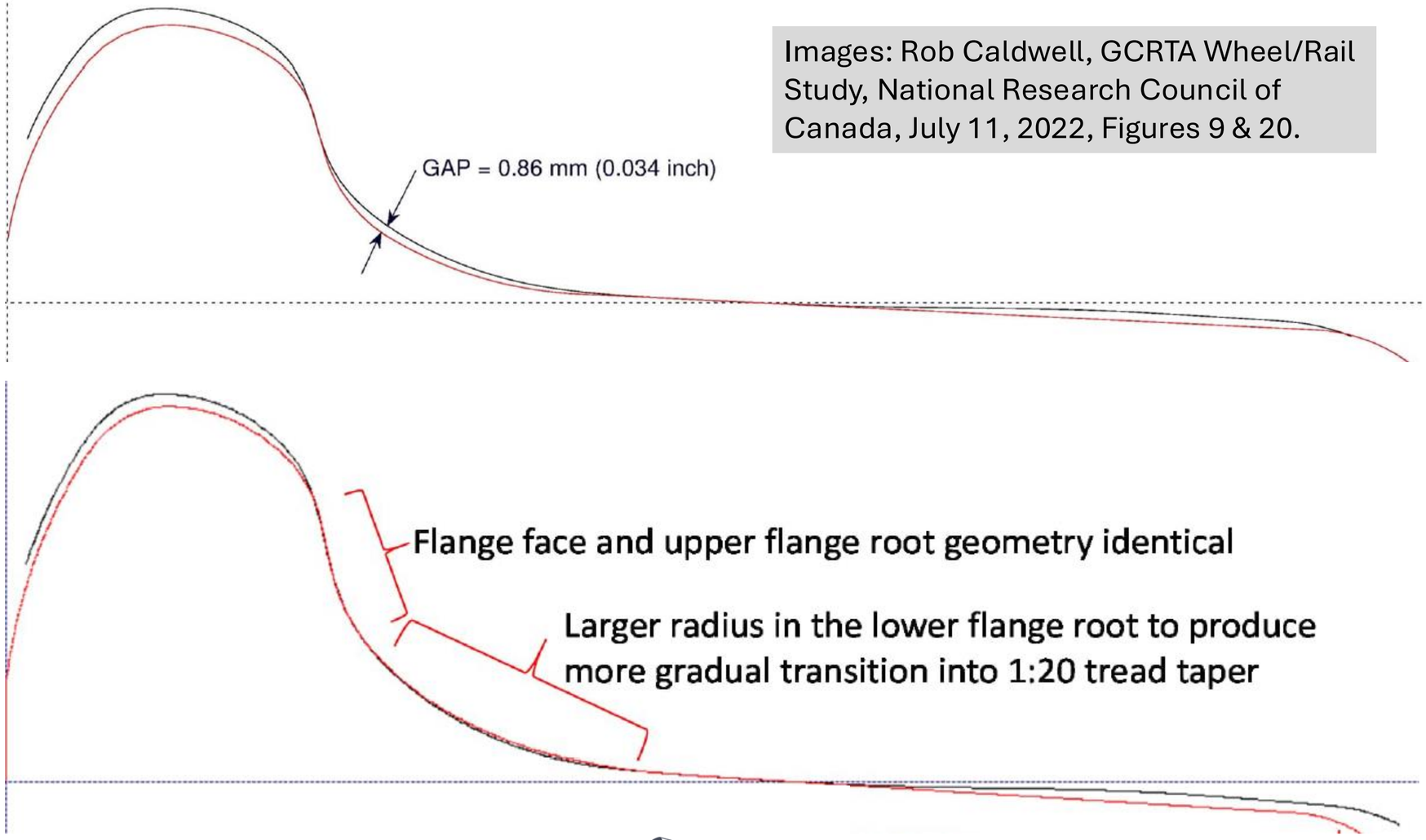
NRC also designed a new wheel profile for RTA

APTA 220 (red) vs. RTA avg worn (black). The worn profile has a more gradual flange root.

The NRC RTA (red) vs. RTA avg worn (black).

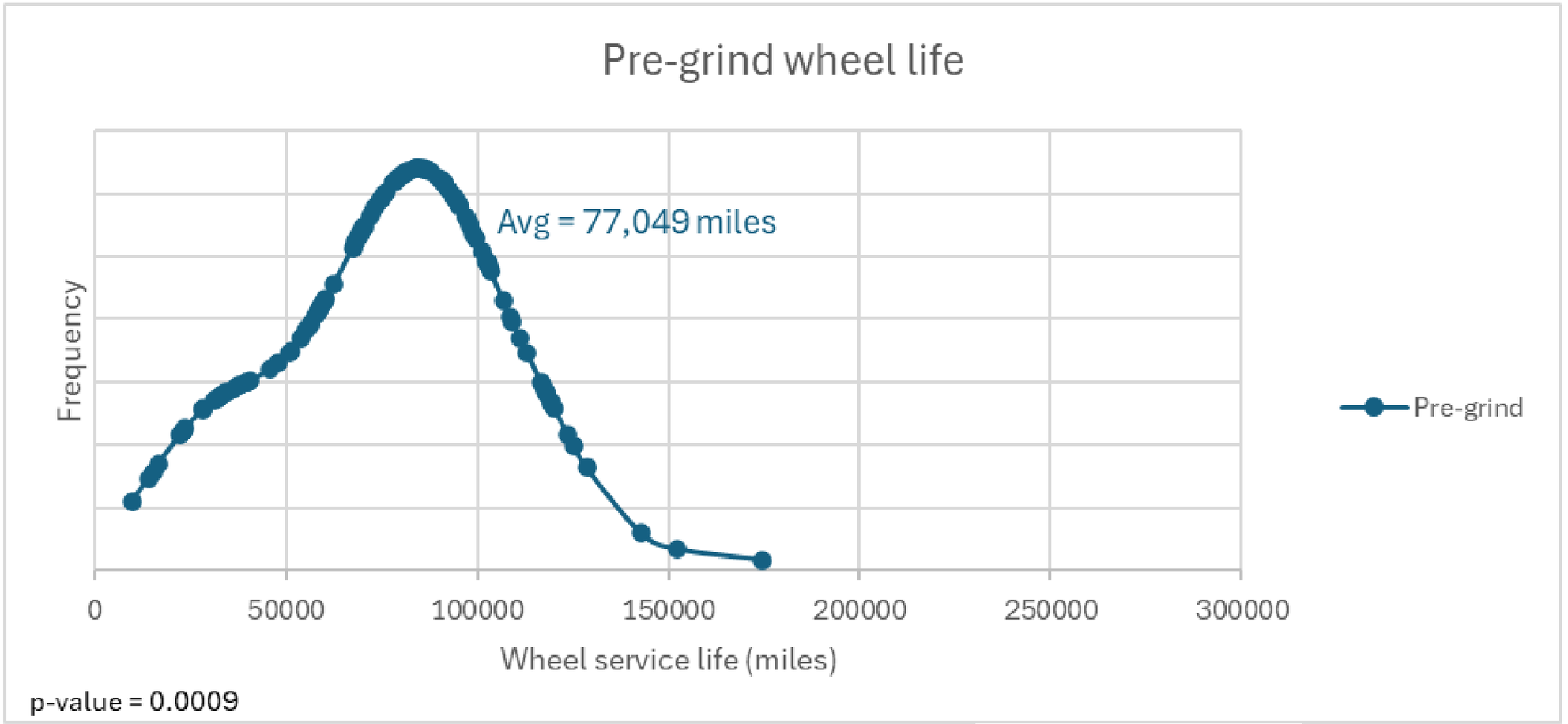
RTA changed their wheel lathe to the NRC RTA in Nov '24

RTA continues to use new APTA 220 wheels in inventory



Images: Rob Caldwell, GCRTA Wheel/Rail Study, National Research Council of Canada, July 11, 2022, Figures 9 & 20.

2) How did rail grinding impact wheel life?



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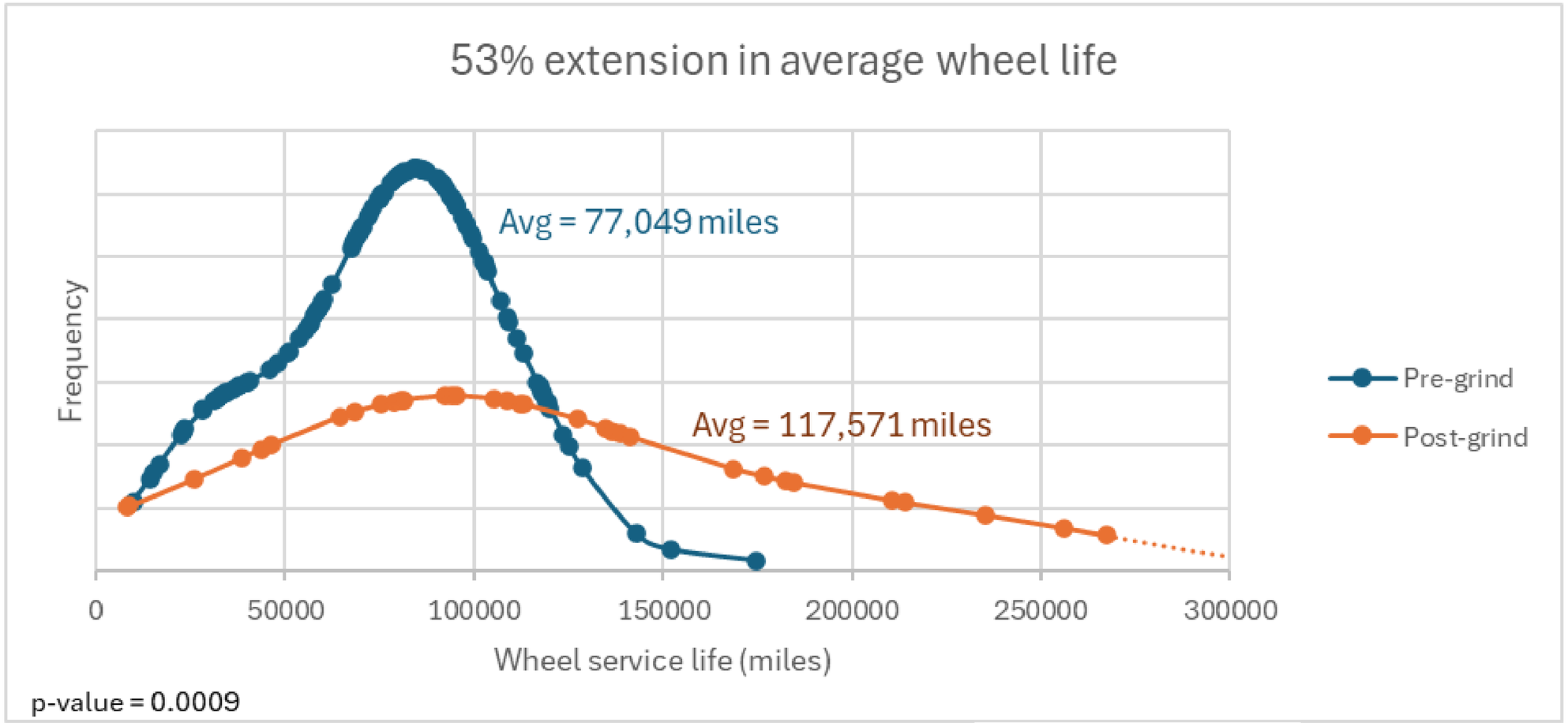

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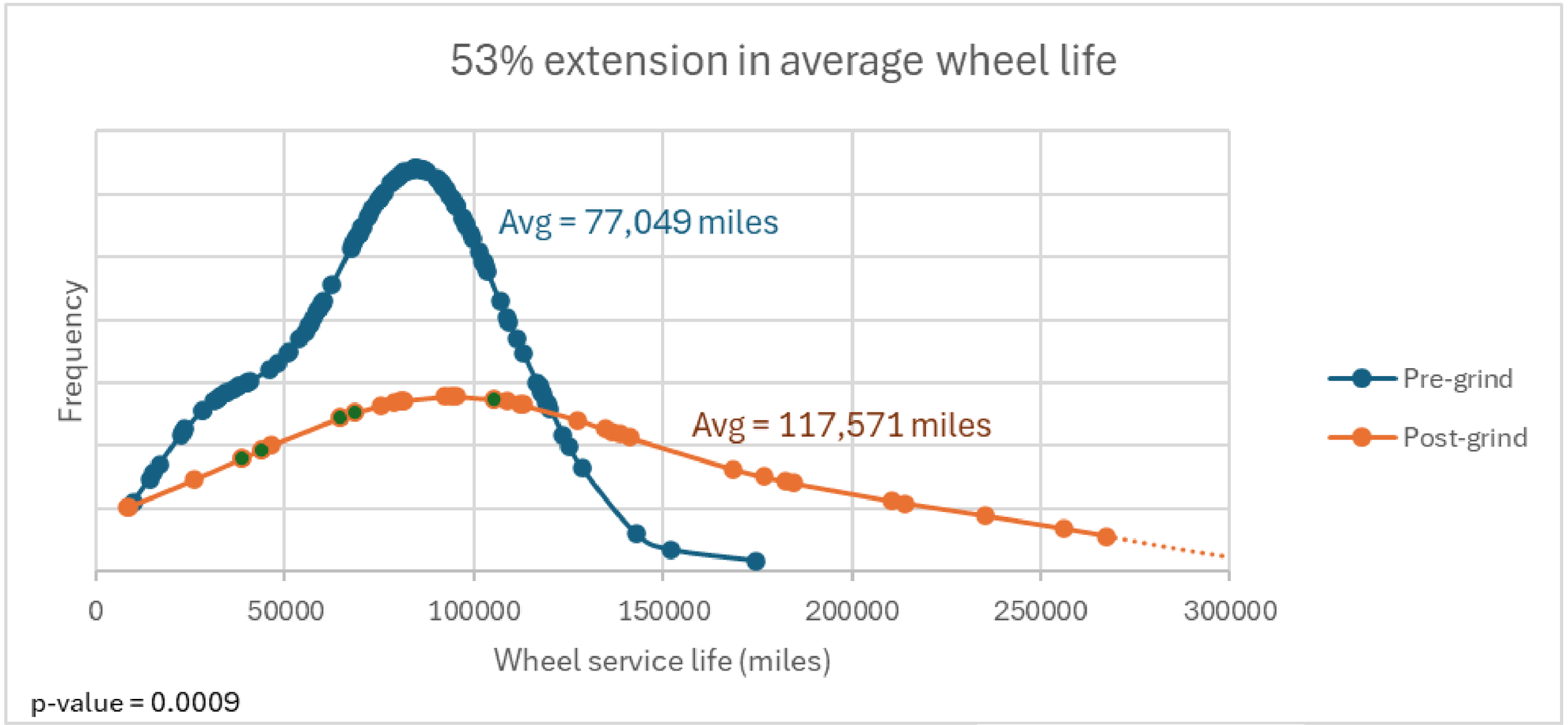
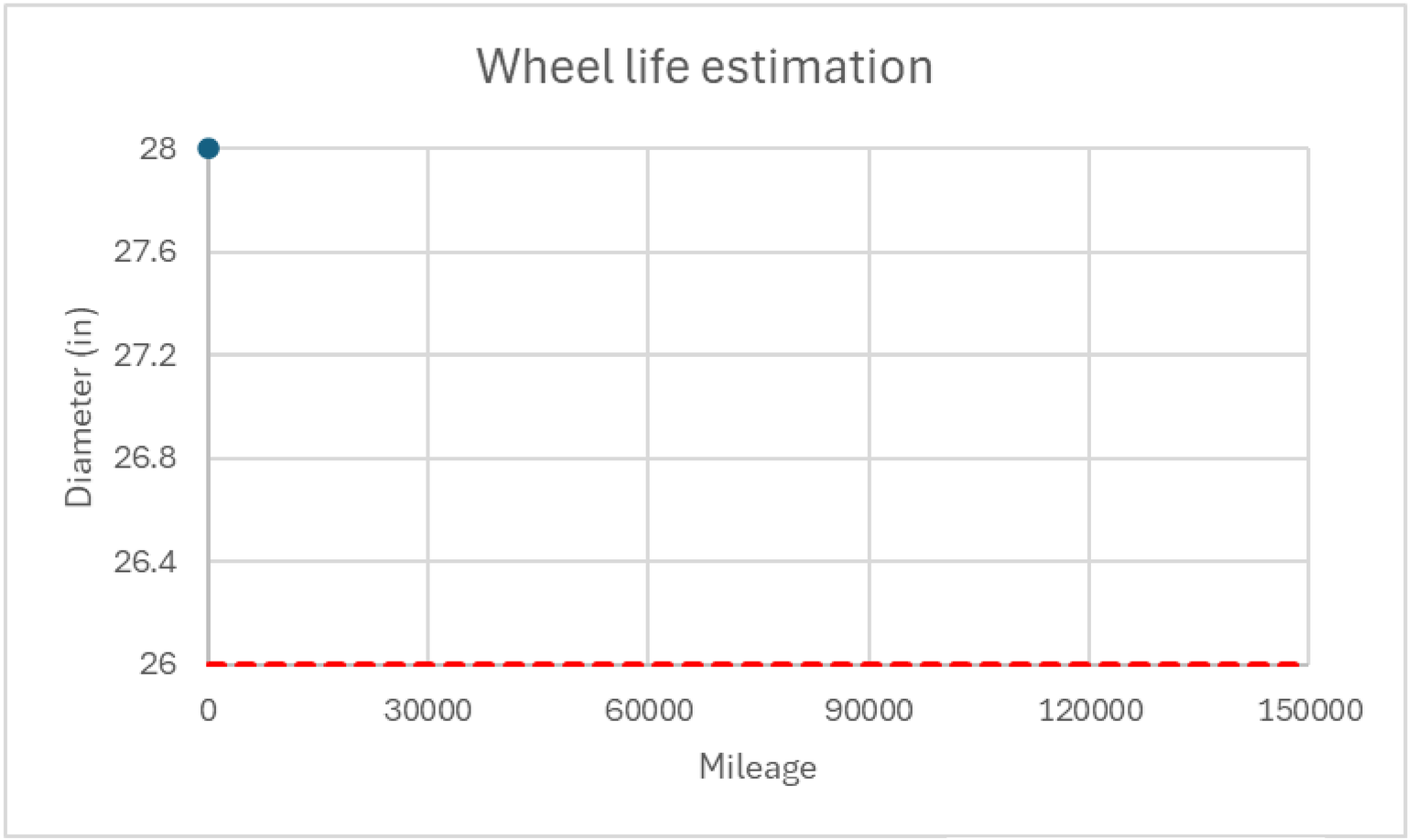


How to estimate wheel life



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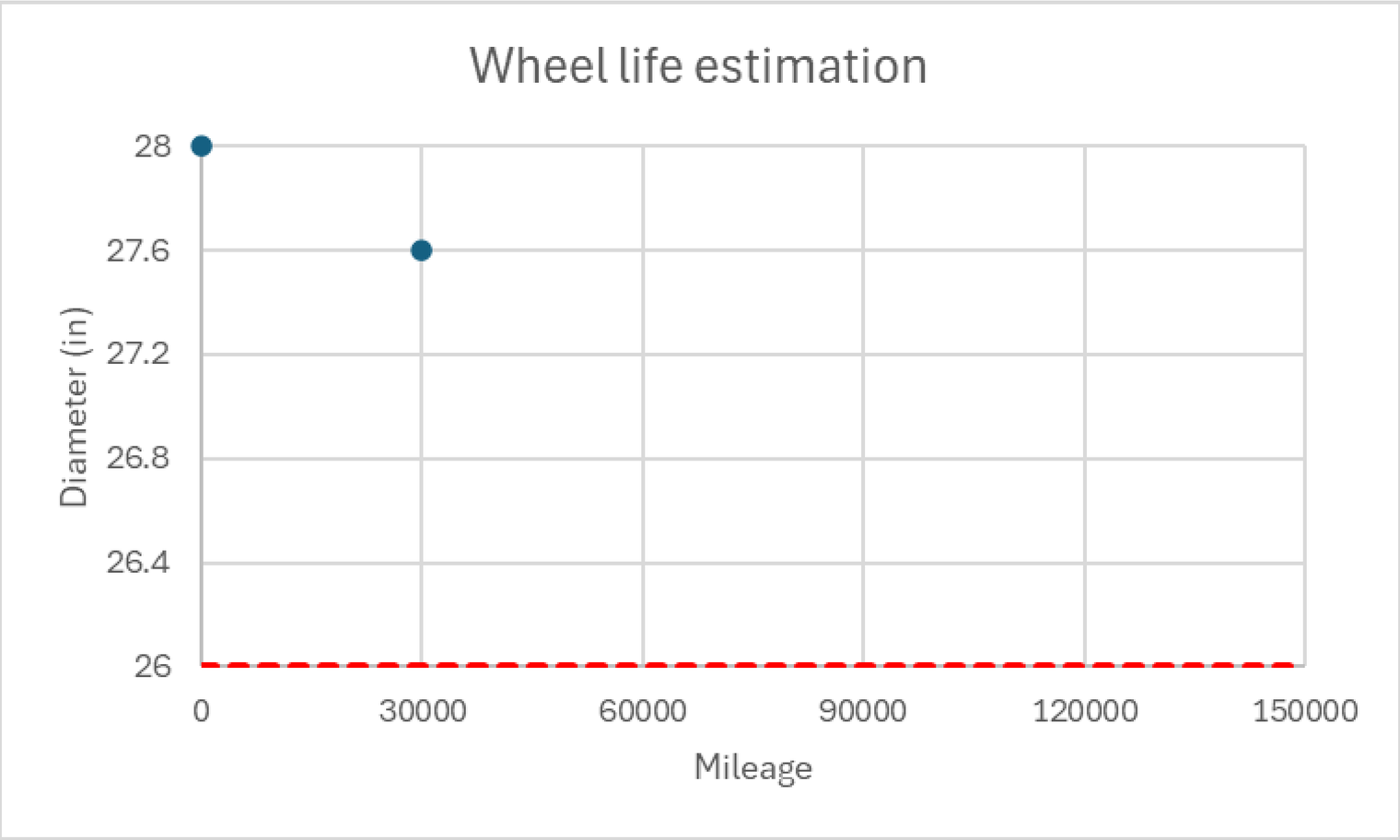

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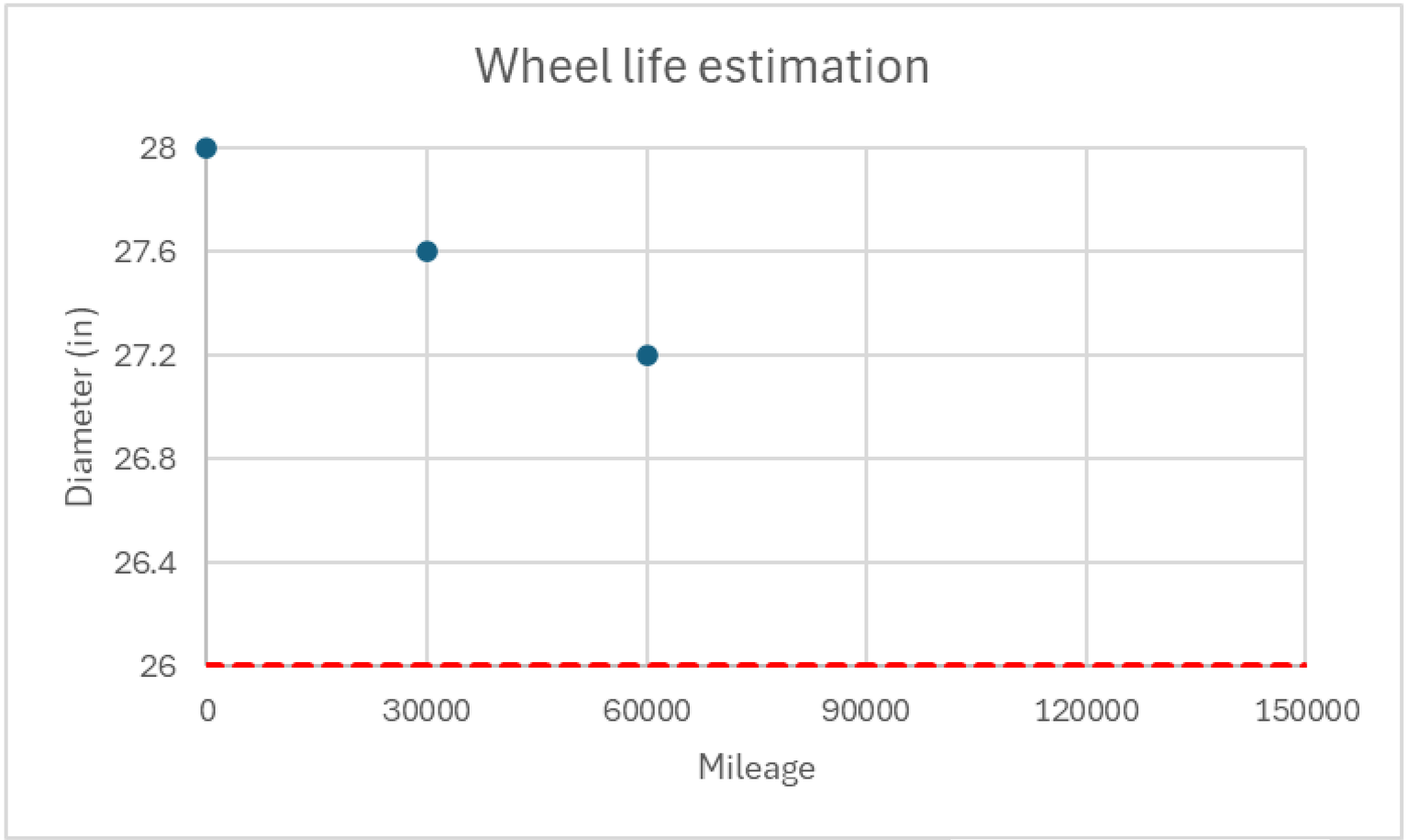

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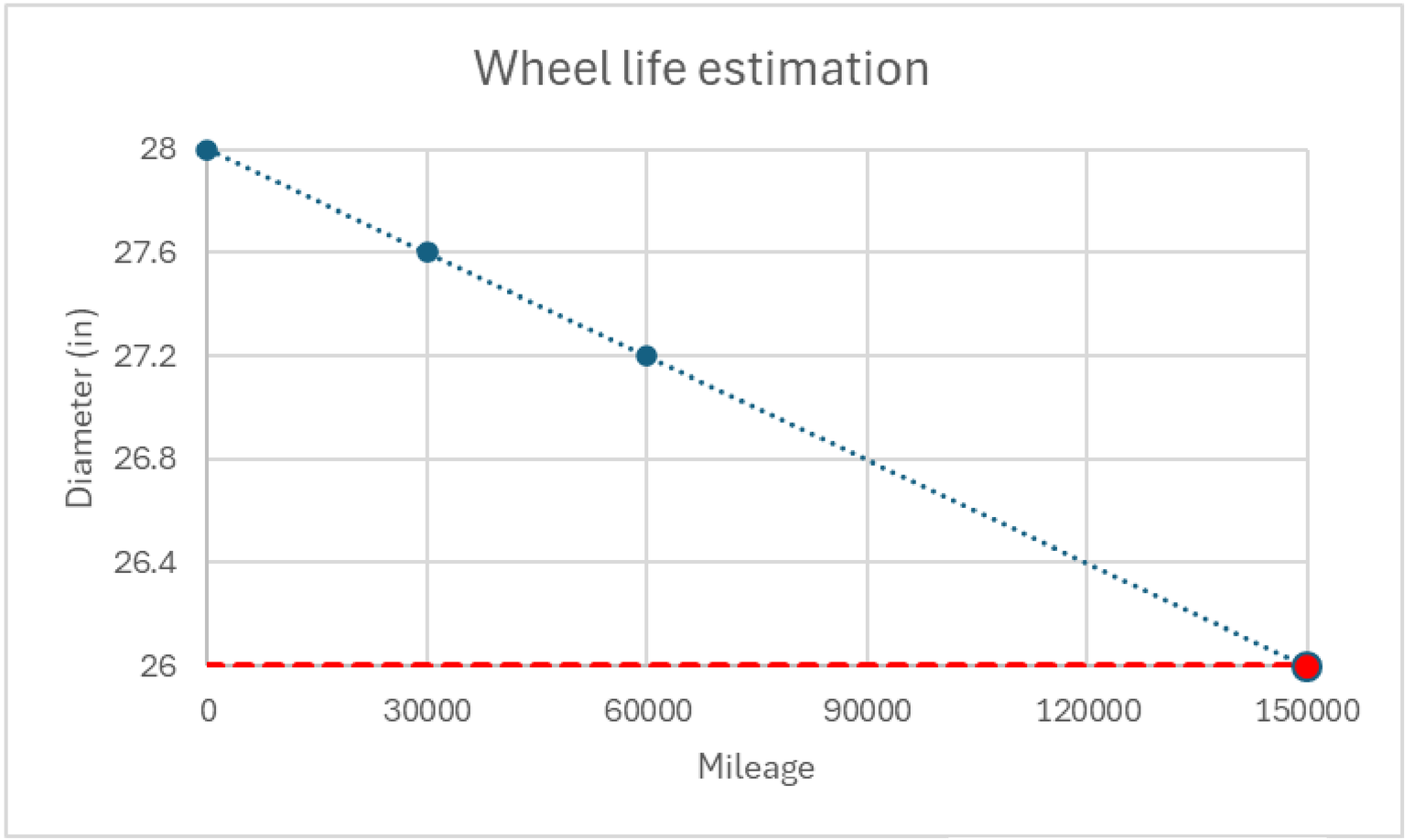

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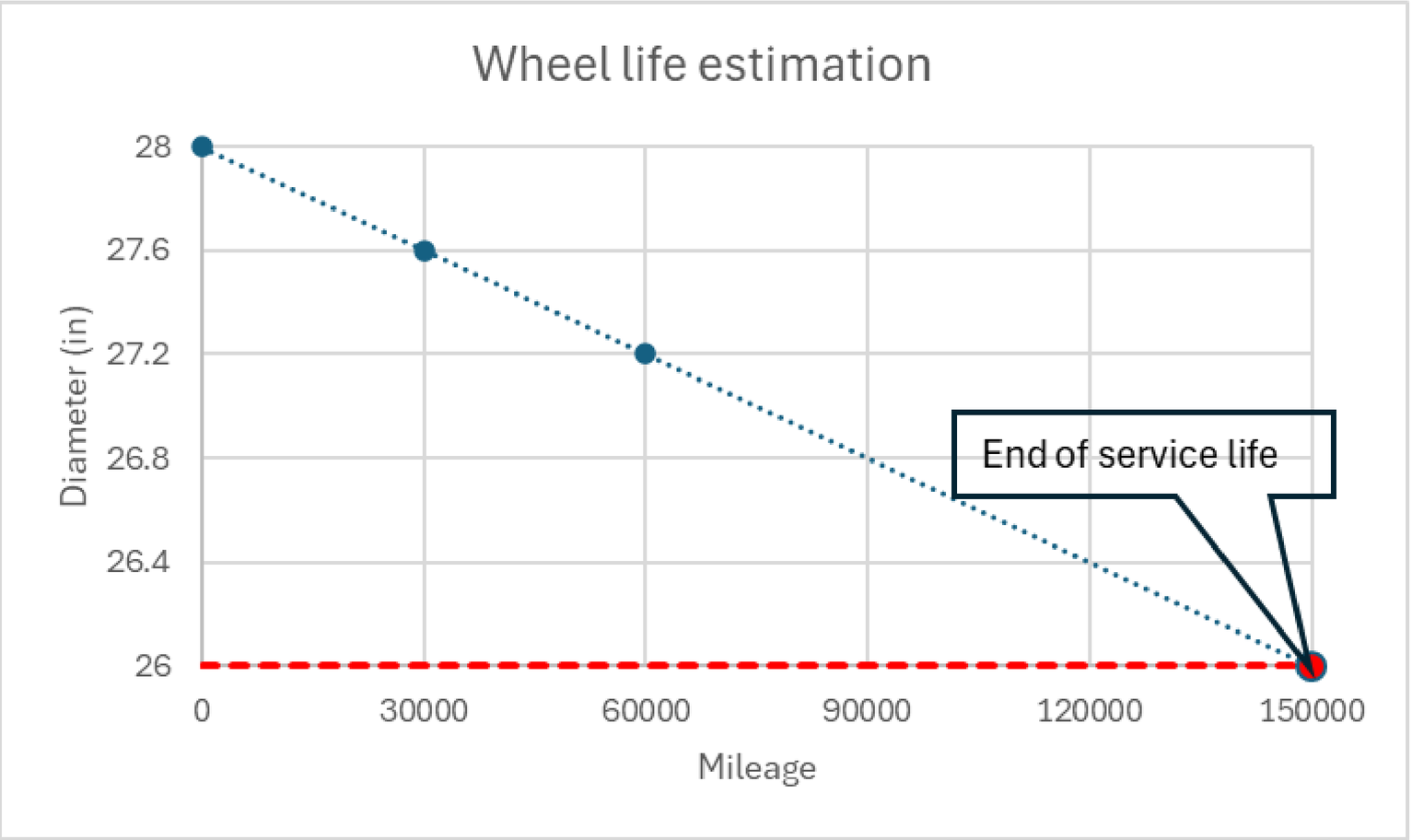
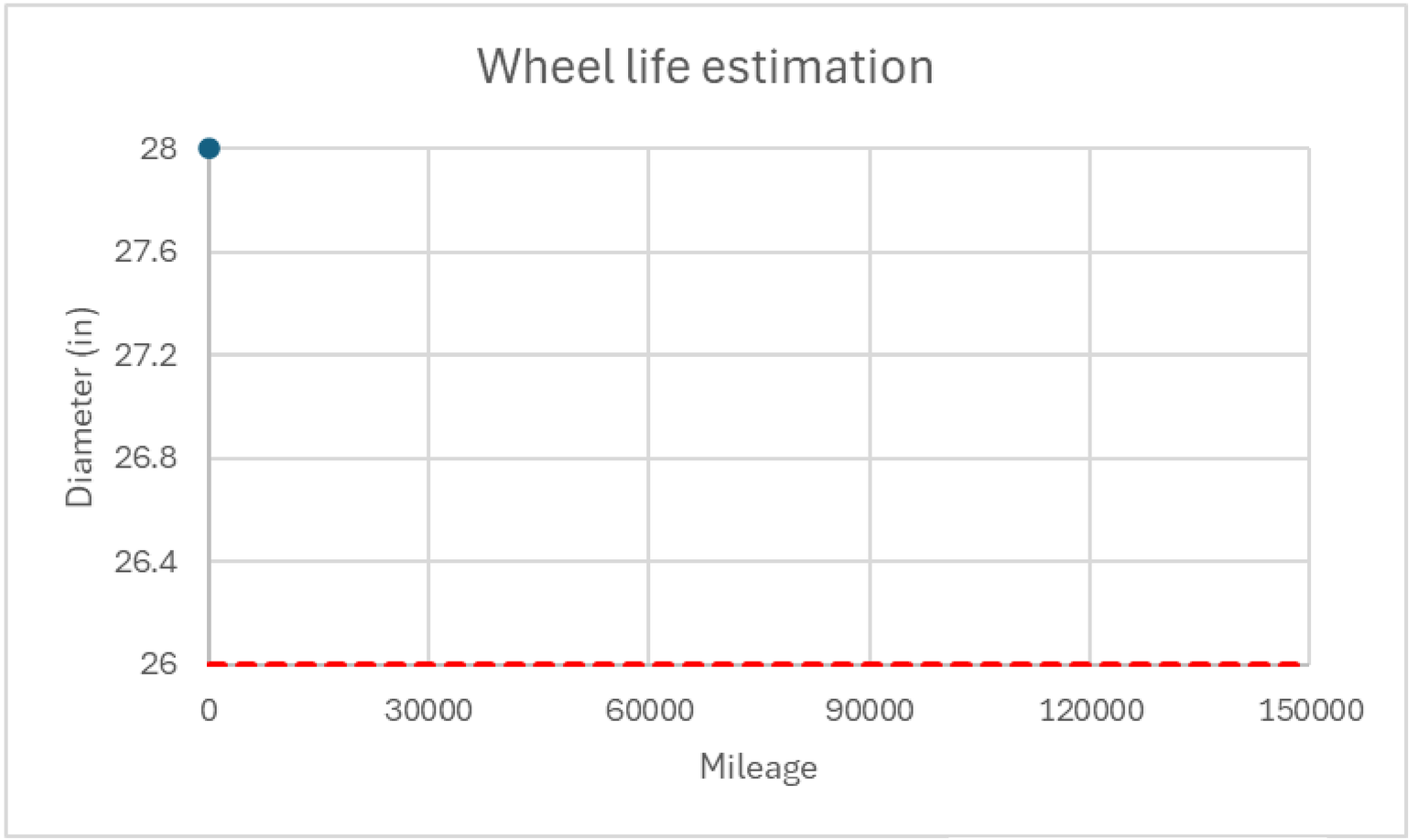


How **NOT** to estimate wheel life



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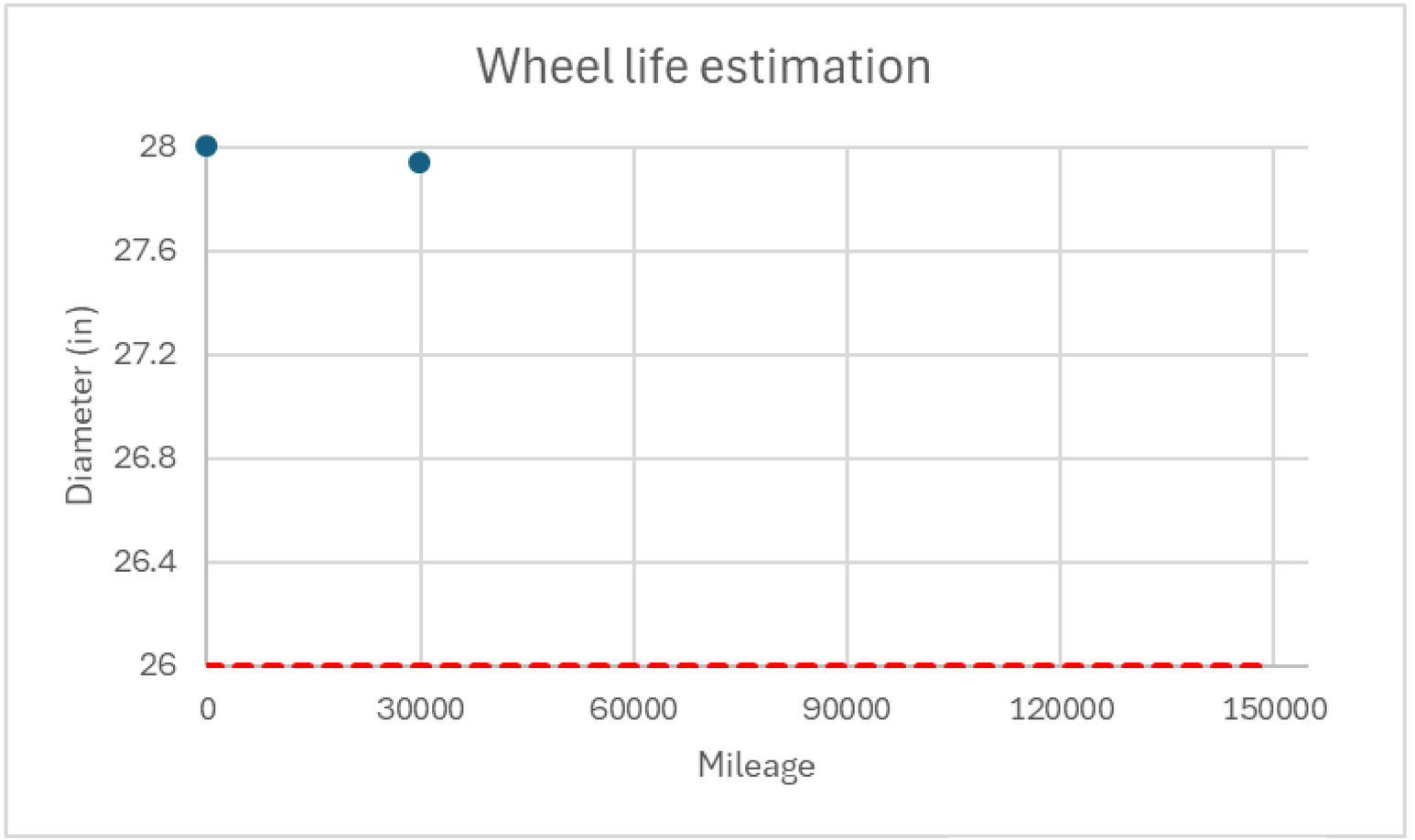

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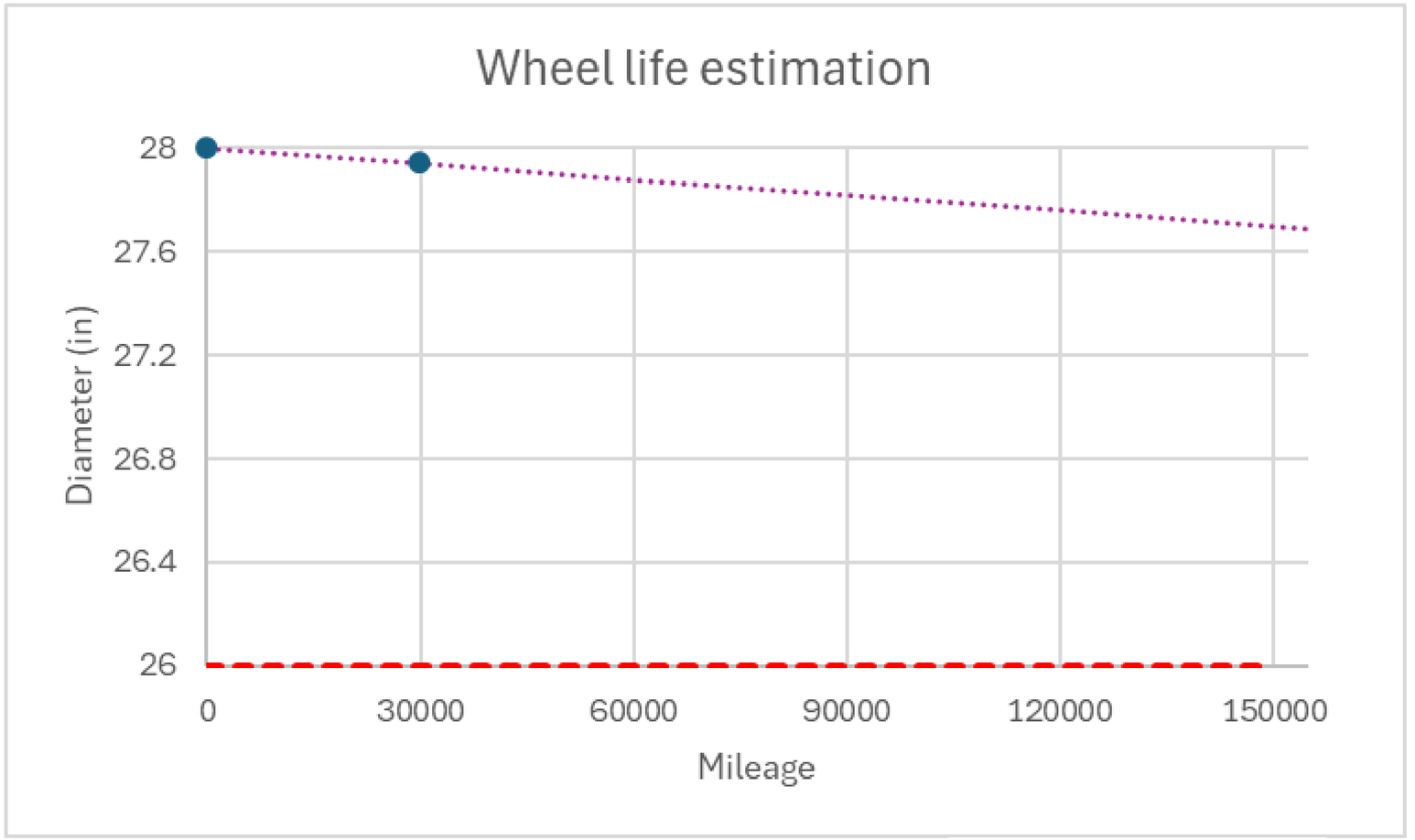

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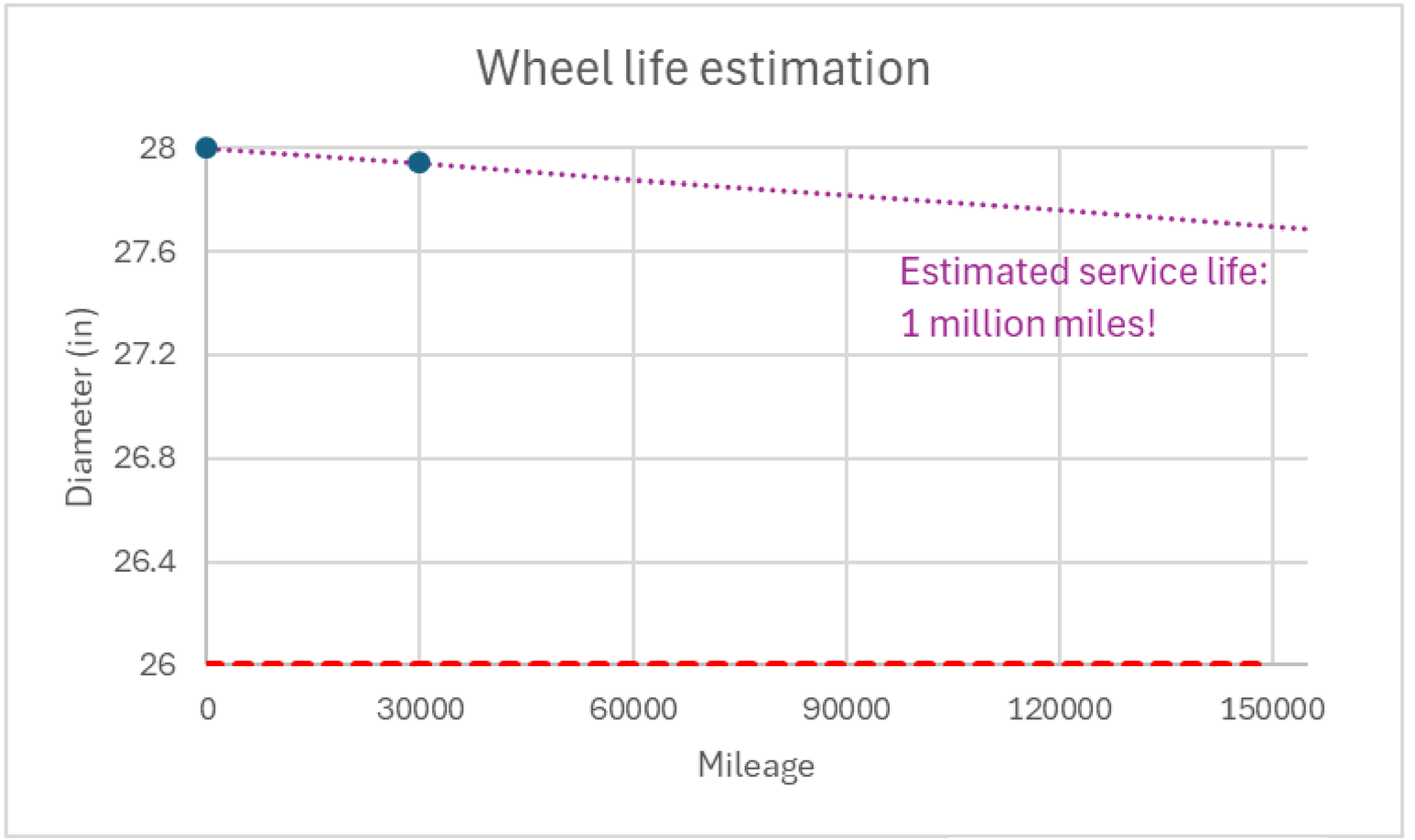

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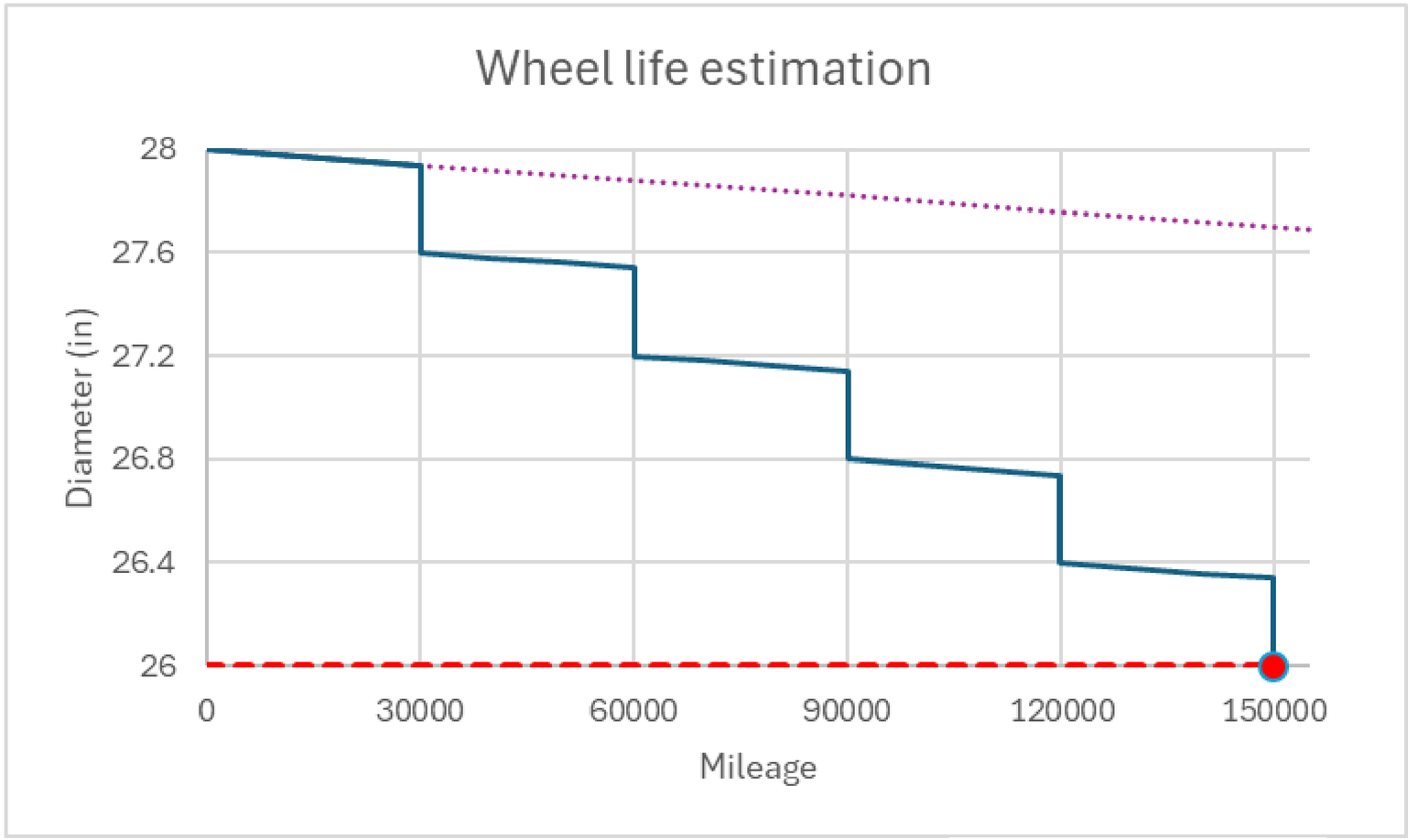

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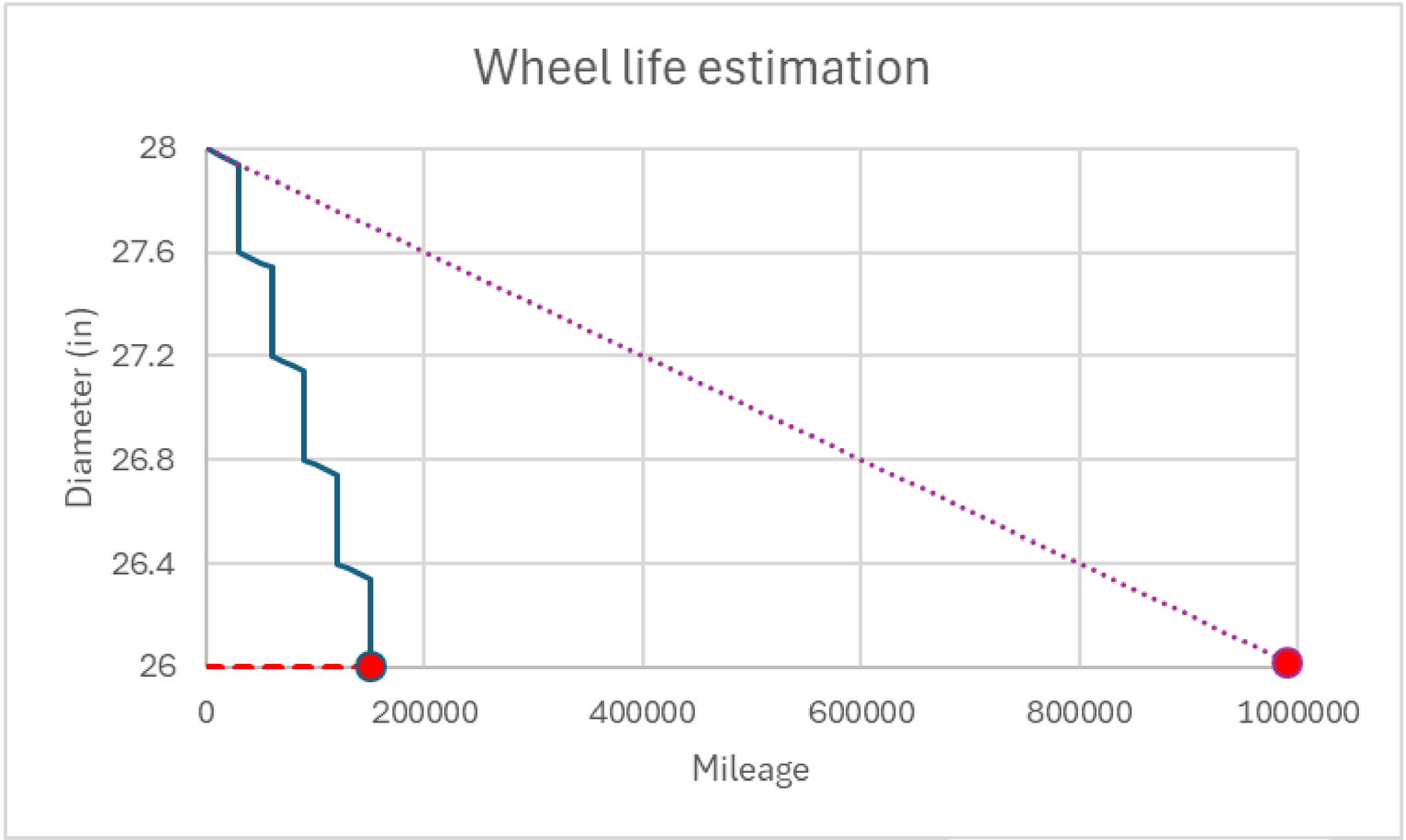
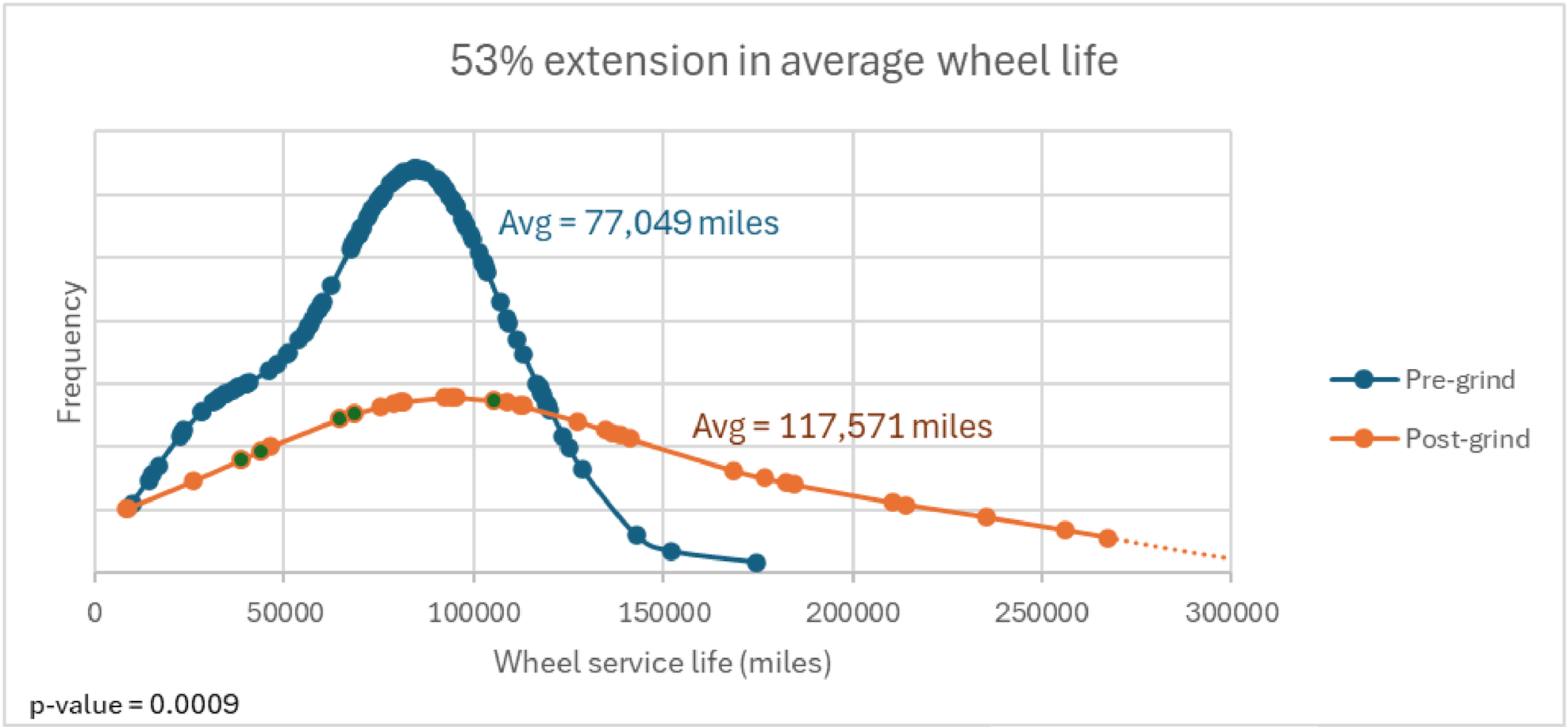


First post-grind wheel changeouts



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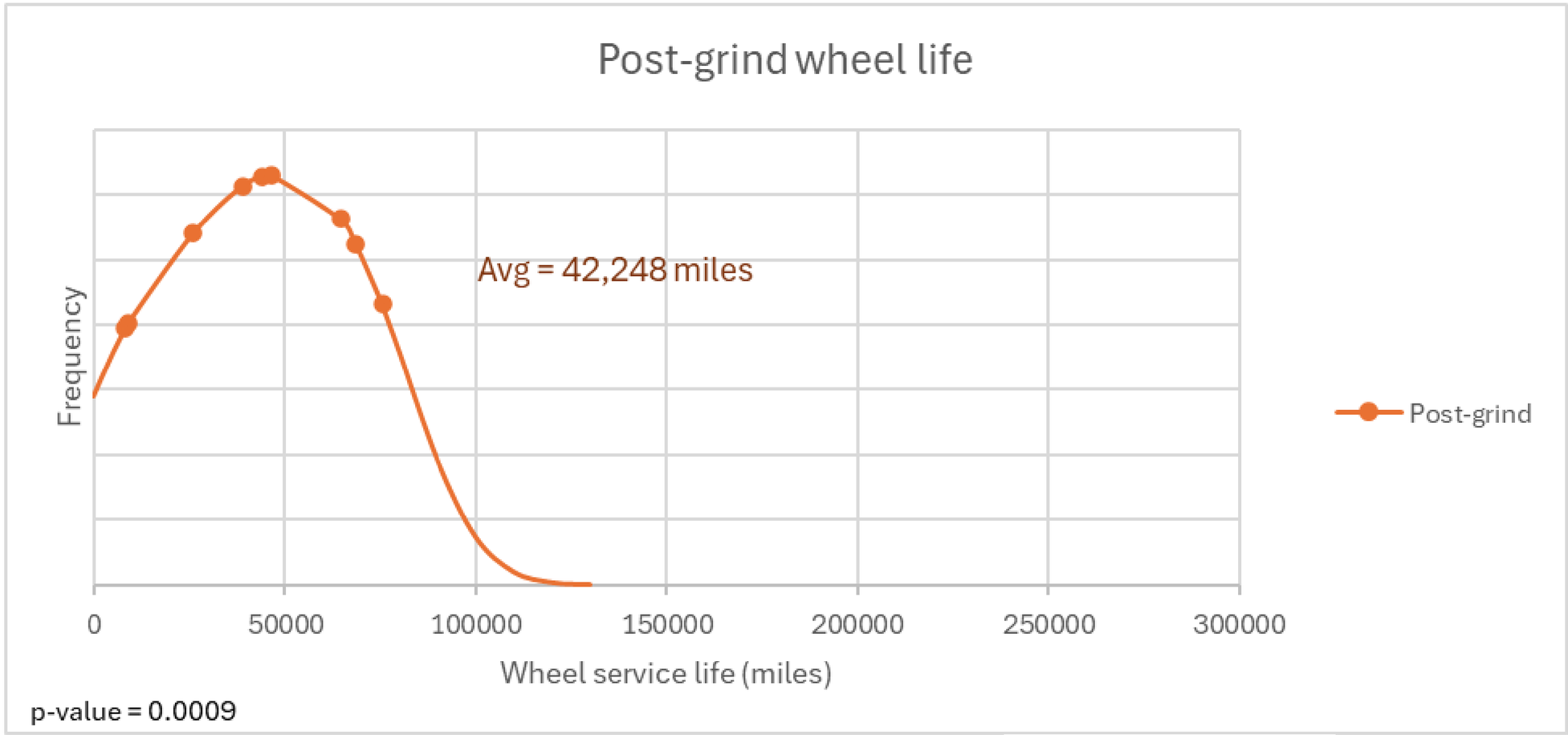

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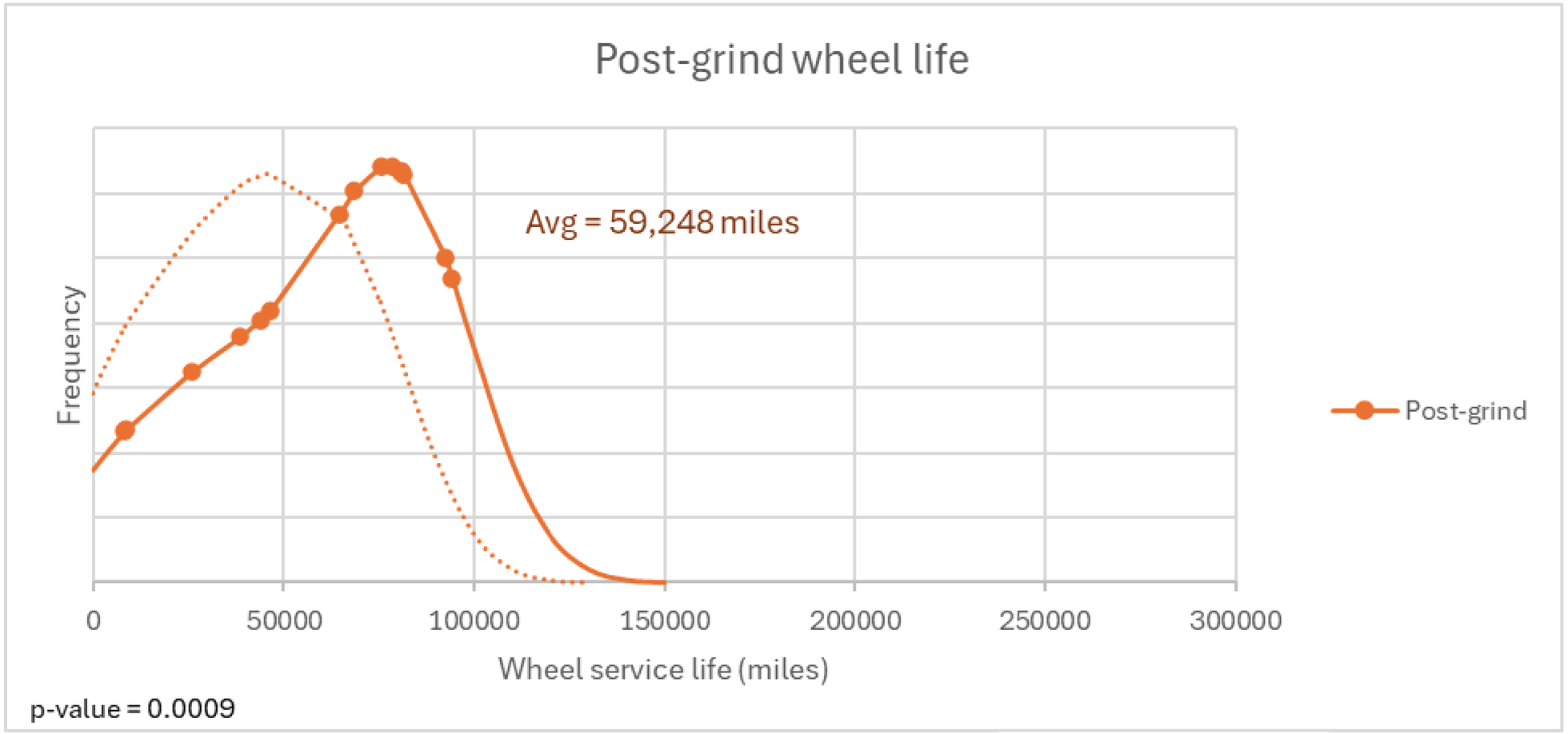

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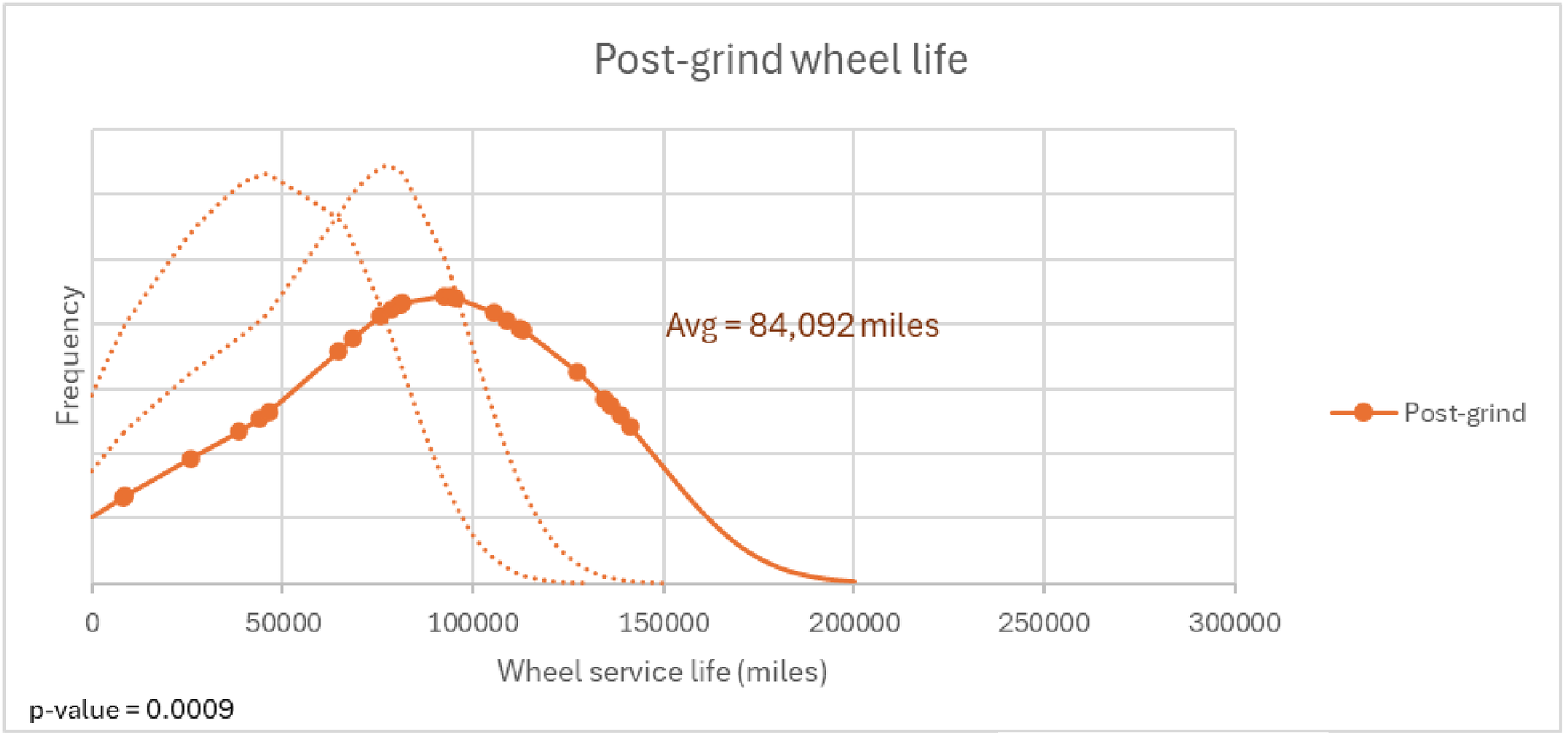

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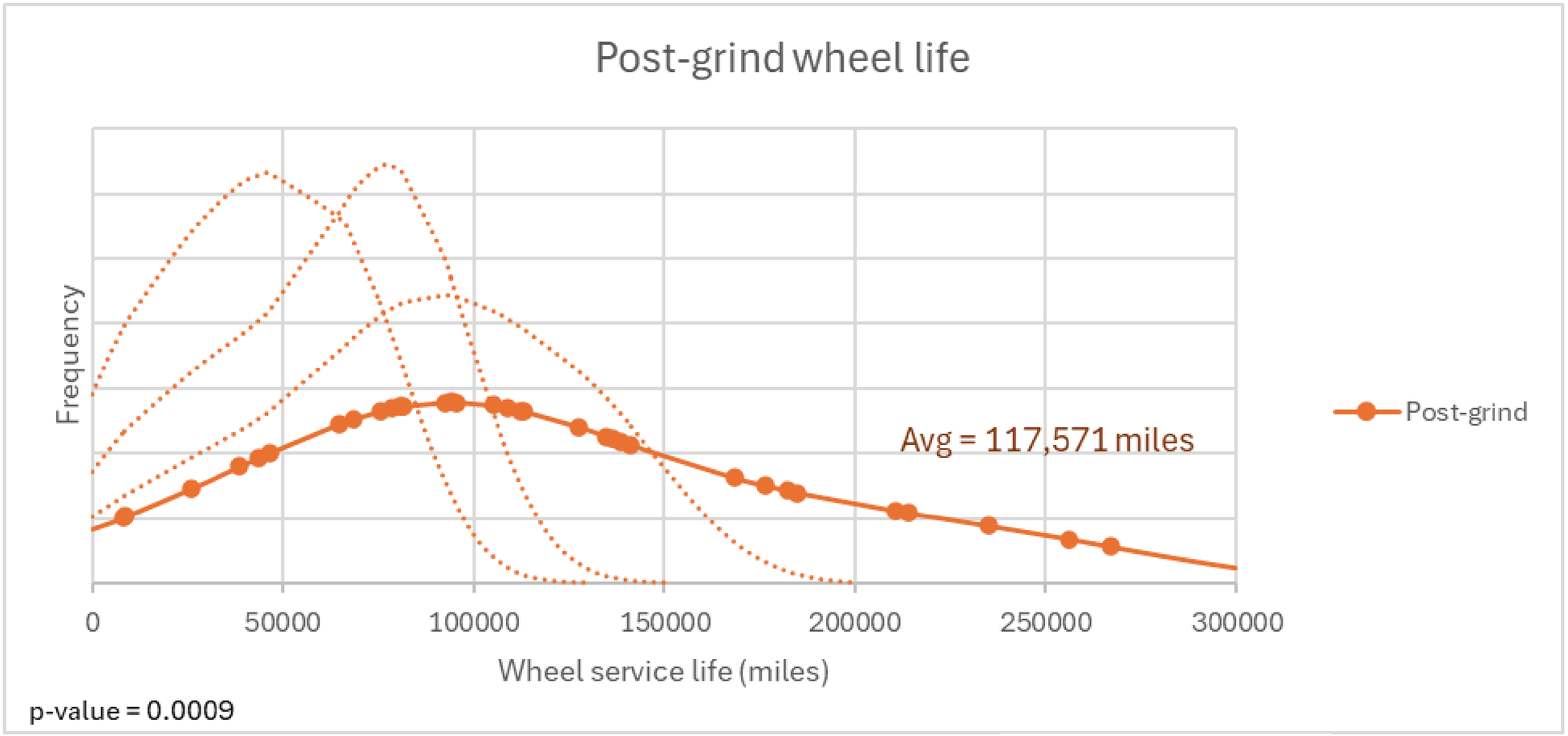
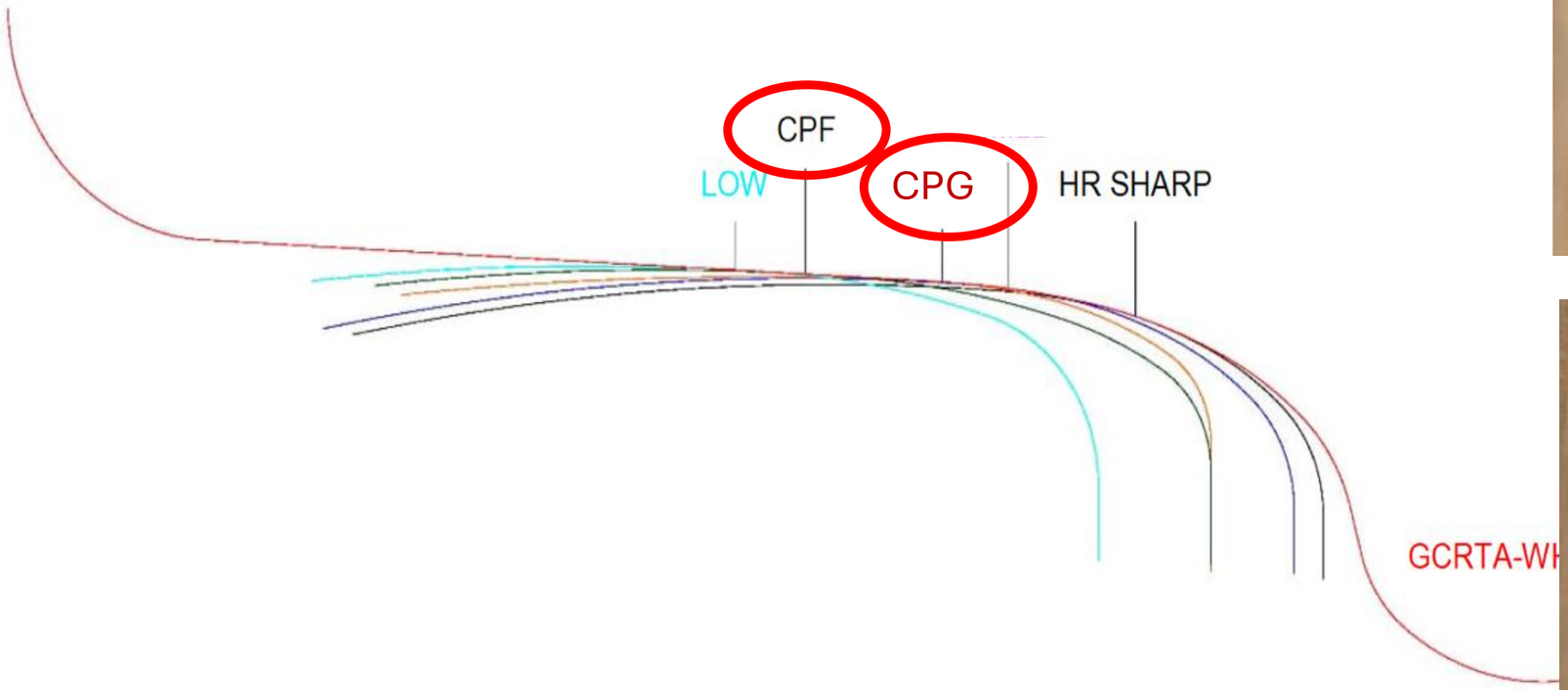


How can we explain the extended wheel life?

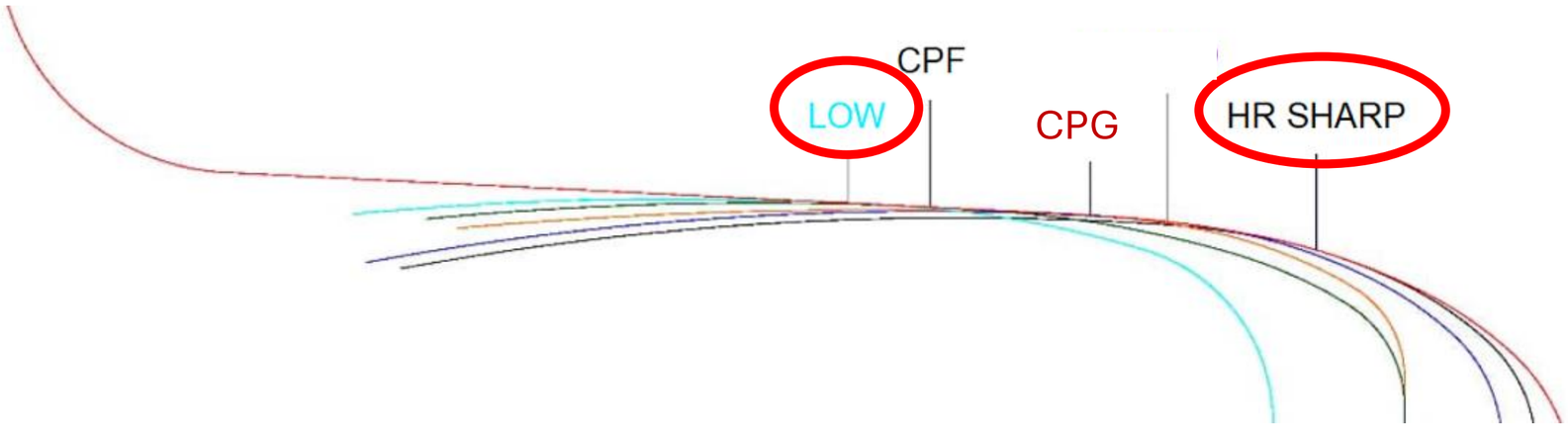
1) Two tangent profiles widen tread contact



How can we explain the extended wheel life?

2) Curve profiles result in better wheelset steering → less wheel/rail friction → less wear

- Low rails — profile changed from flat to crowned, so wheels contact the rail center (lesser rolling radius)
- High rails — profile emphasizes gage-corner contact (greater rolling radius)



How can we explain the extended wheel life?

3) Truing wheels to the new NRC RTA profile results in better wheelset steering → less wheel/rail friction → less wear.

- Previously, wheels trued to the APTA 220 profile had to go through a break-in period to achieve the worn profile.
- Wheelsets are typically trued 3 to 4 times.
- Truing to the RTA profile started in Nov 2024 (new wheels are still the APTA 220).

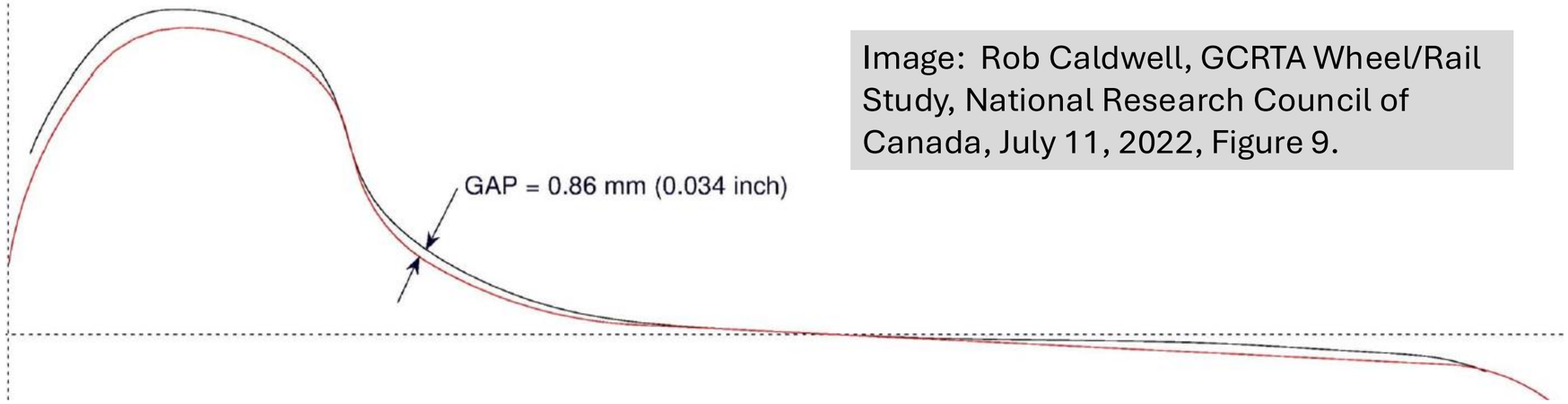


Image: Rob Caldwell, GCRTA Wheel/Rail Study, National Research Council of Canada, July 11, 2022, Figure 9.

APTA 220 (red) vs.
RTA avg worn (black).

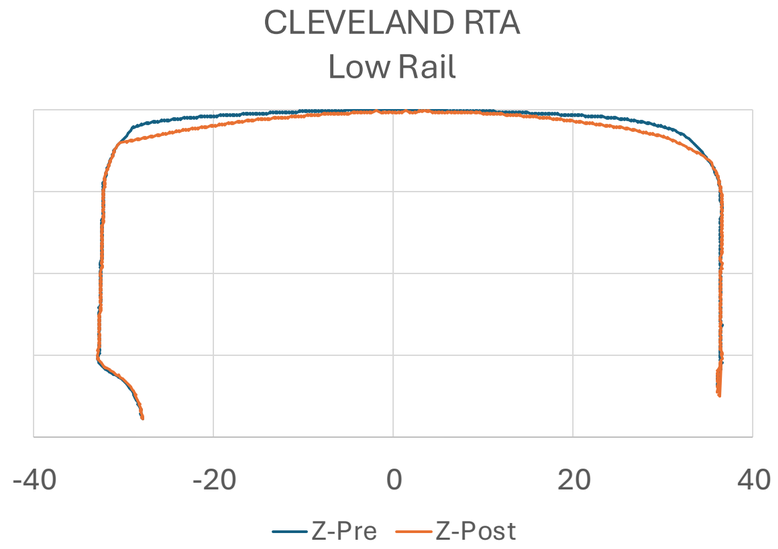
3) Rail grinding: what measurements make sense?

In Cleveland, our primary grind quality method was visual inspection: did the grinding result in the desired wheel contact?

Answer - mostly yes.

We did collect KLD rail profile data, which we used to calculate GQI. But these calculations were more of a mathematical exercise – GQI was not used.

Rail MiniProfs were to illustrate in presentations and reports; they did not guide our grinding work.

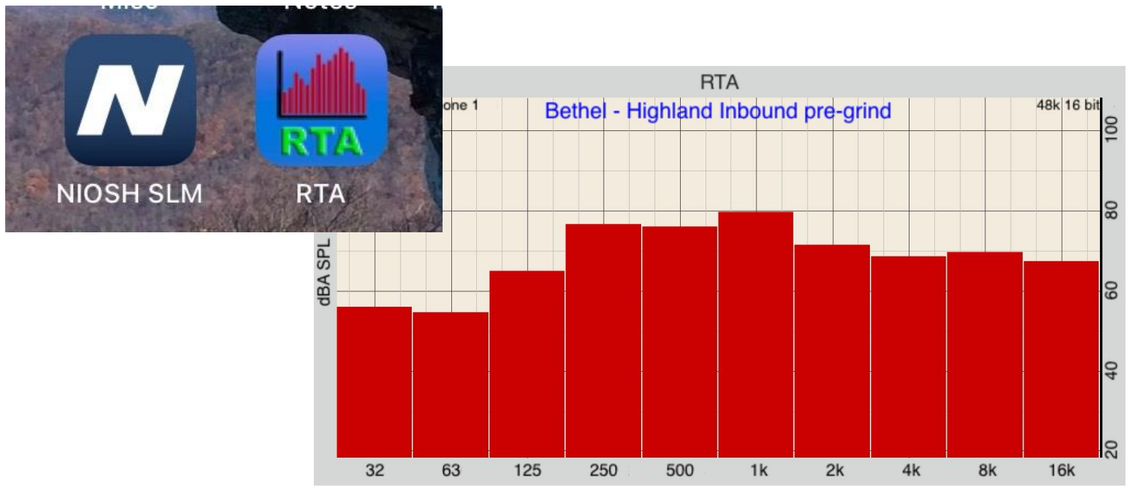


Rail grinding: what measurements make sense?

Another rail transit had more demanding quality specifications:

1. Sound (wheel noise)

Specification: Did not have a max decibel reading; instead, they required a final pass with finer-grit (acoustic) stones in sensitive areas.



2. Surface roughness measurements

Specification: *Finished surface (Ra) roughness, in contact band:*

< 8 microns standard

< 5 microns acoustic

outside contact band:

< 10 microns

Rail grinding: what measurements make sense?

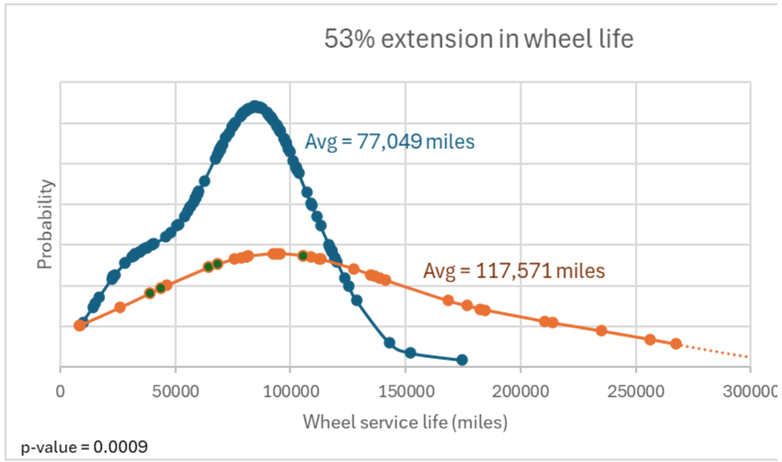
3. Longitudinal roughness using a CAT (corrugation analyzer trolley)

Specification: Max longitudinal variation of 0.02 mm over 200mm

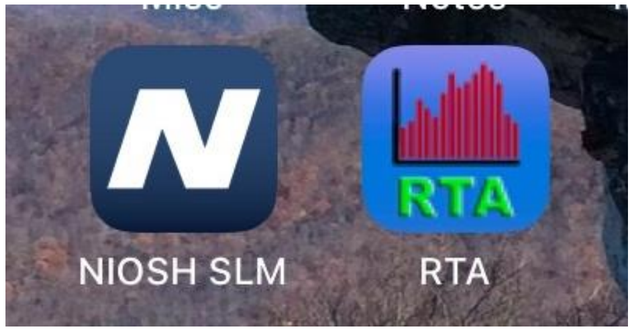
4. MiniProf rail profiles

Specification: Maximum transverse tolerance of +/- 0.5 mm (relative to design profile)

Questions - GCRTA grinding campaign



Discussion – what rail measurements are appropriate?



How did rail grinding impact wheel life?