

A New Wheel Profile for North American Freight Railroads: AAR-2A

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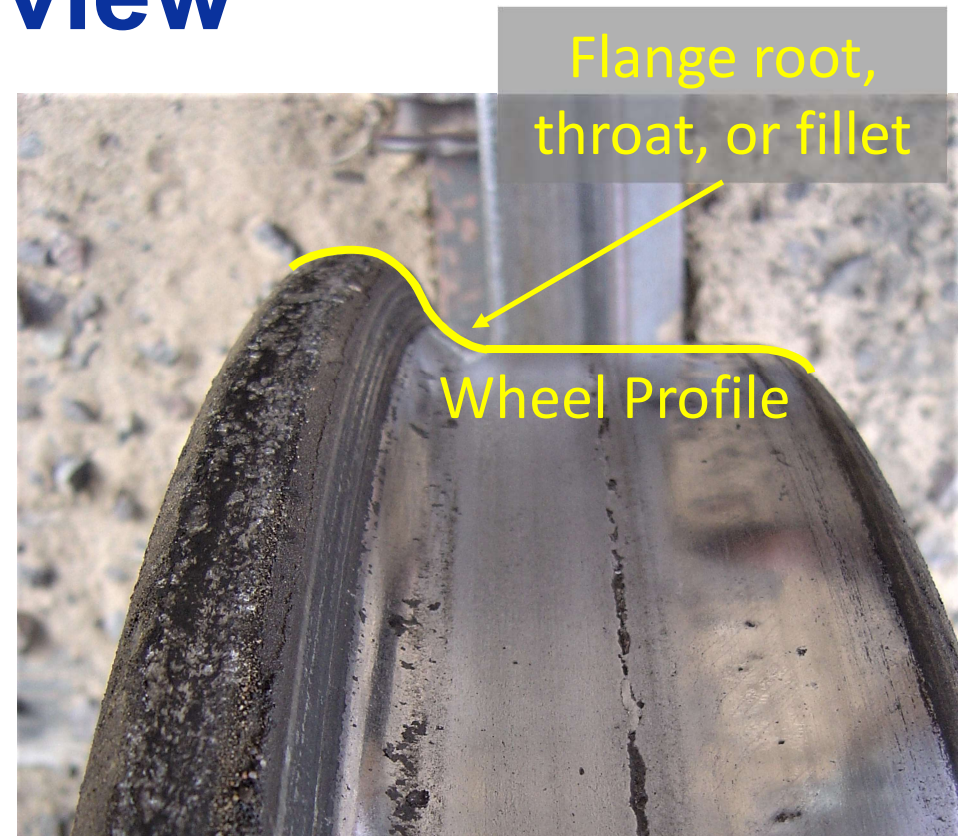
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WRI 2018

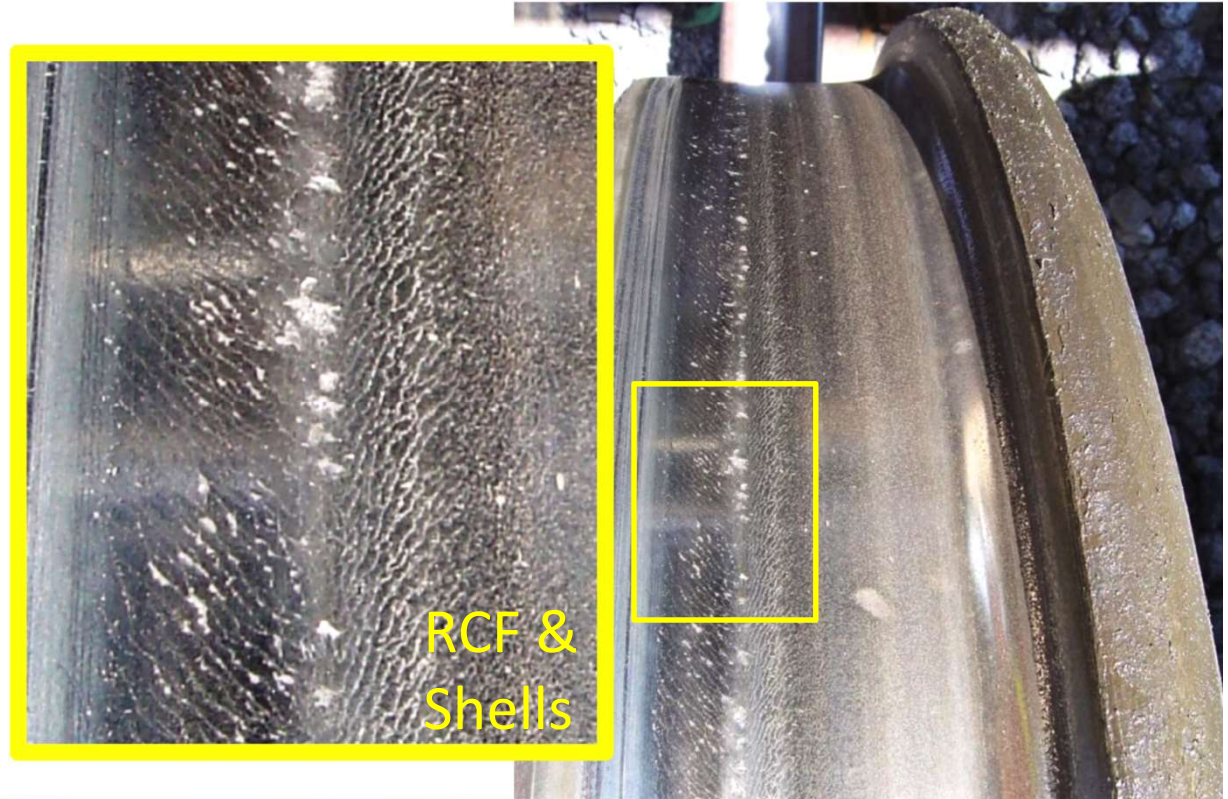
Overview

- **Background**
 - Wheel/rail profiles, contact conditions, wear
 - Relevant history
- **Development and design**
- **Modeling**
- **Testing**
- **Implementation**



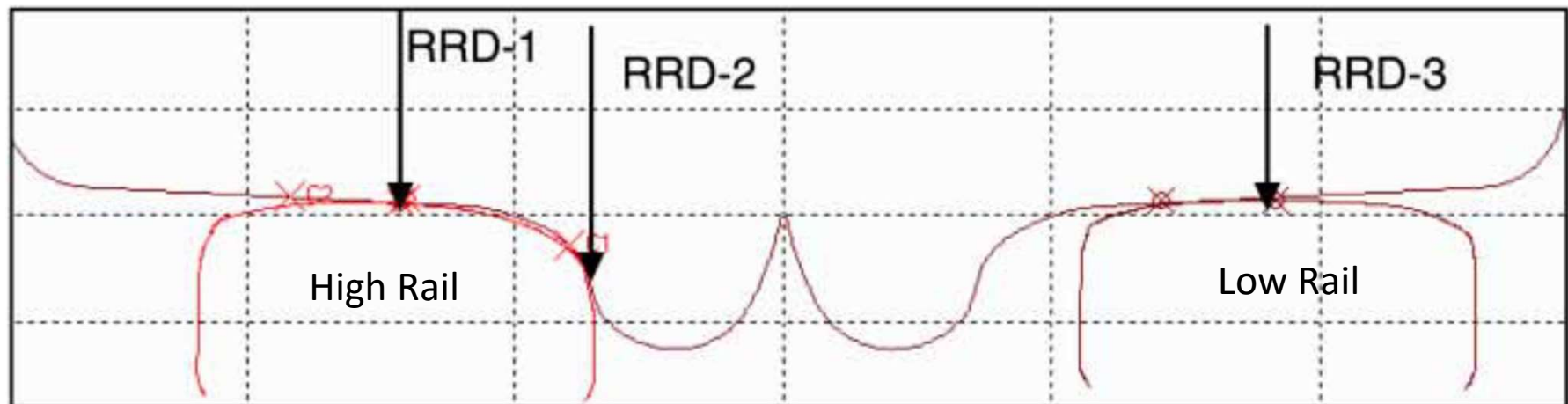
Wheel and Rail Profiles

- Safety/Guidance
- Performance
 - Wear
 - Surface damage
 - Train energy consumption
 - Vehicle and track maintenance



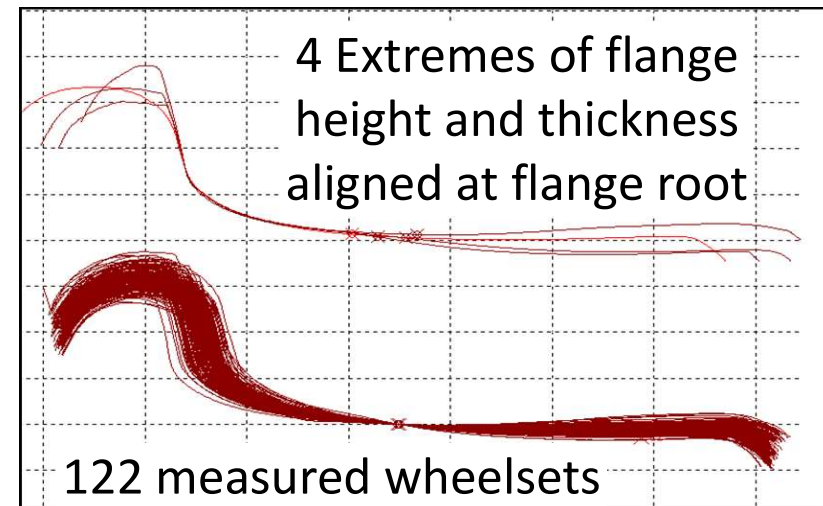
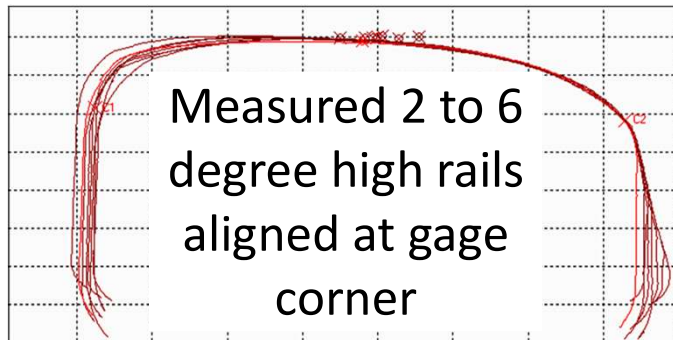
Conformality

- **High rail contact condition**
 - Flange contact, >2 deg curve
 - 2-point, conformal, 1-point
- **Metrics**
 - Maximum gap
 - Rolling radius difference



Wear

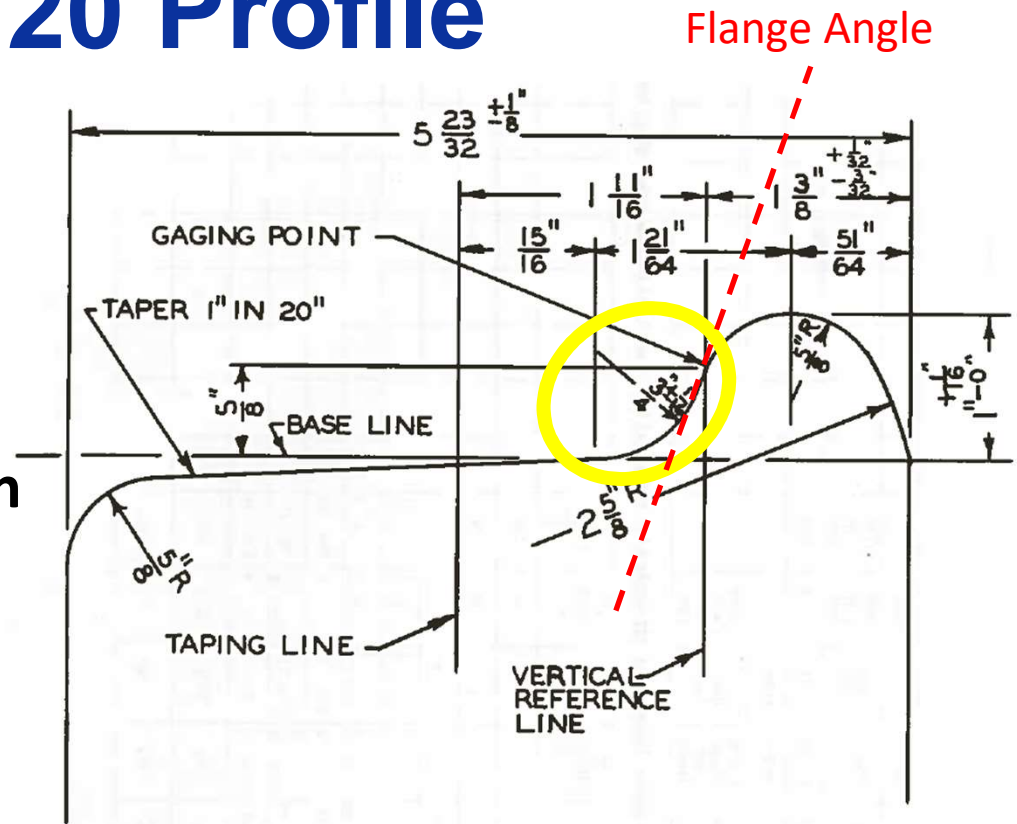
- **Wheels and rails wear to a common conformal shape**
- **Majority of wheels and rails are worn**
- **Annual replacement rates:**
 - **About 10% wheels, 3% rail**



AAR 1:20 Profile

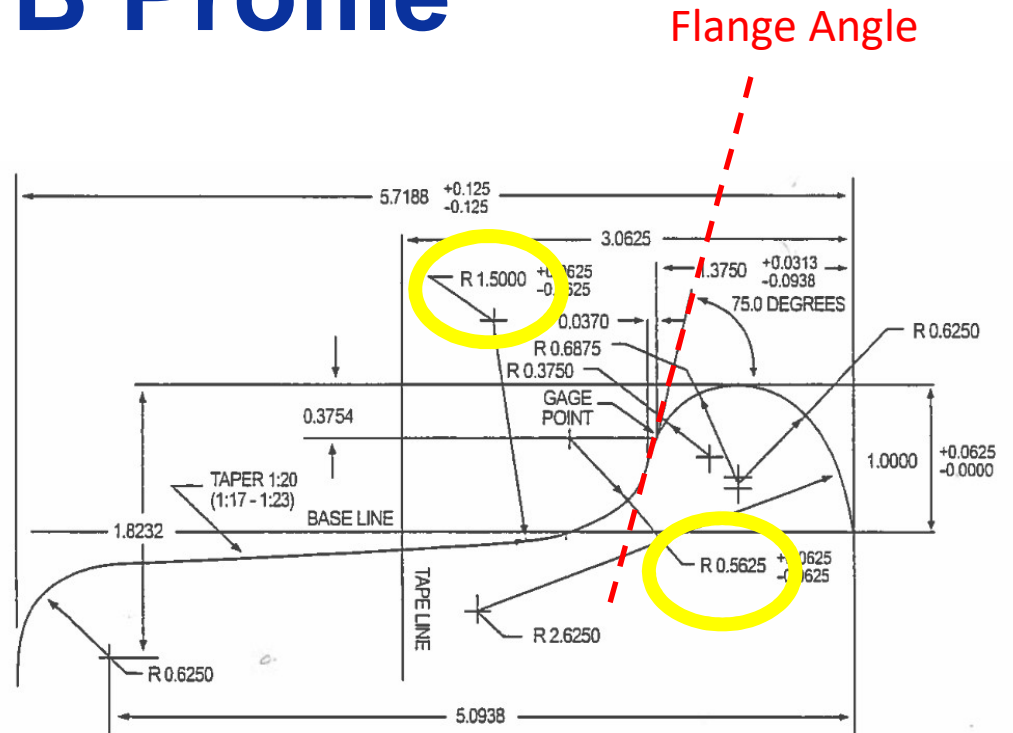
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- Pre-1990
- Improvement from cylindrical profiles
- 70 degree flange angle
- Flange fillet radius 0.75 inch
- 1:20 tread taper



AAR-1B Profile

- 1990 to current
- 75 degree flange angle
- Multiple flange fillet radii
- 1:20 tread taper
- Developed in 1980s from measured worn wheel profiles



Flange Angle



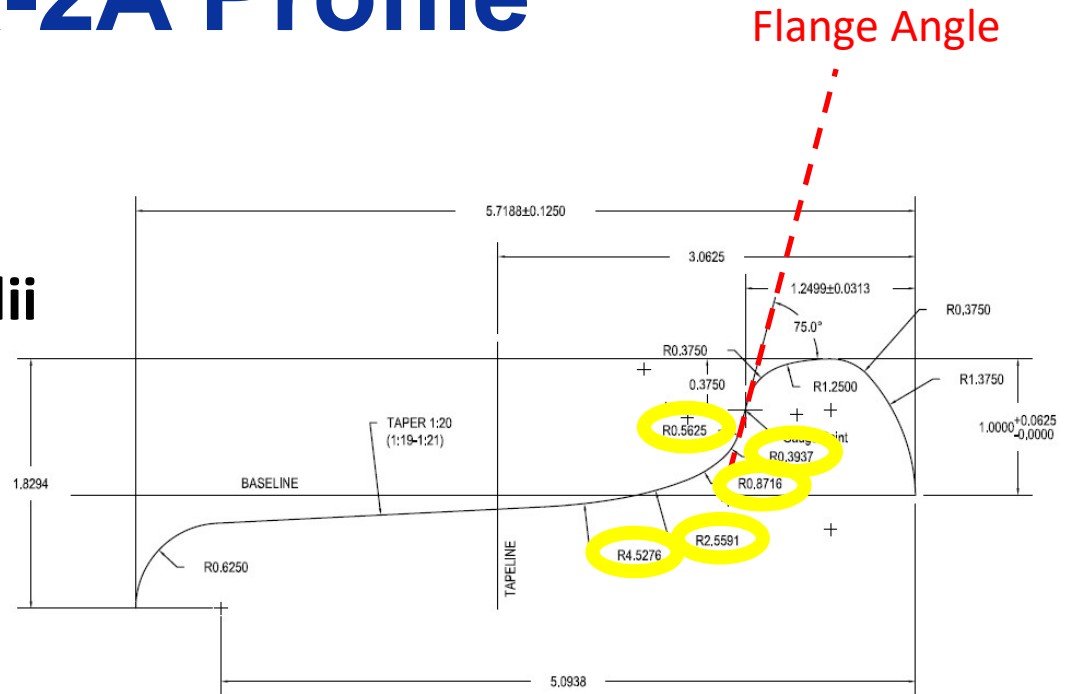
AAR-1B Profile

- **Original version called AAR-1 (1 of 4 candidate profiles)**
 - 4 intersecting arcs in flange fillet, max radius 20 inches
- **Simulation + Testing at TTC**
 - Candidates showed improved curving performance and rolling resistance but lower hunting threshold than AAR 1:20
 - Hunting onset 49 mph for AAR-1 vs 70 mph for AAR 1:20
- **Revised versions to improve stability called AAR-1A and AAR-1B**
- **Revenue service testing**
 - Improvements in wear rate



AAR-2A Profile

- 2016 to ?
- 75 degree flange angle
- Multiple flange fillet radii
- 1:20 tread taper
- Developed in 2000s from measured worn wheel profiles

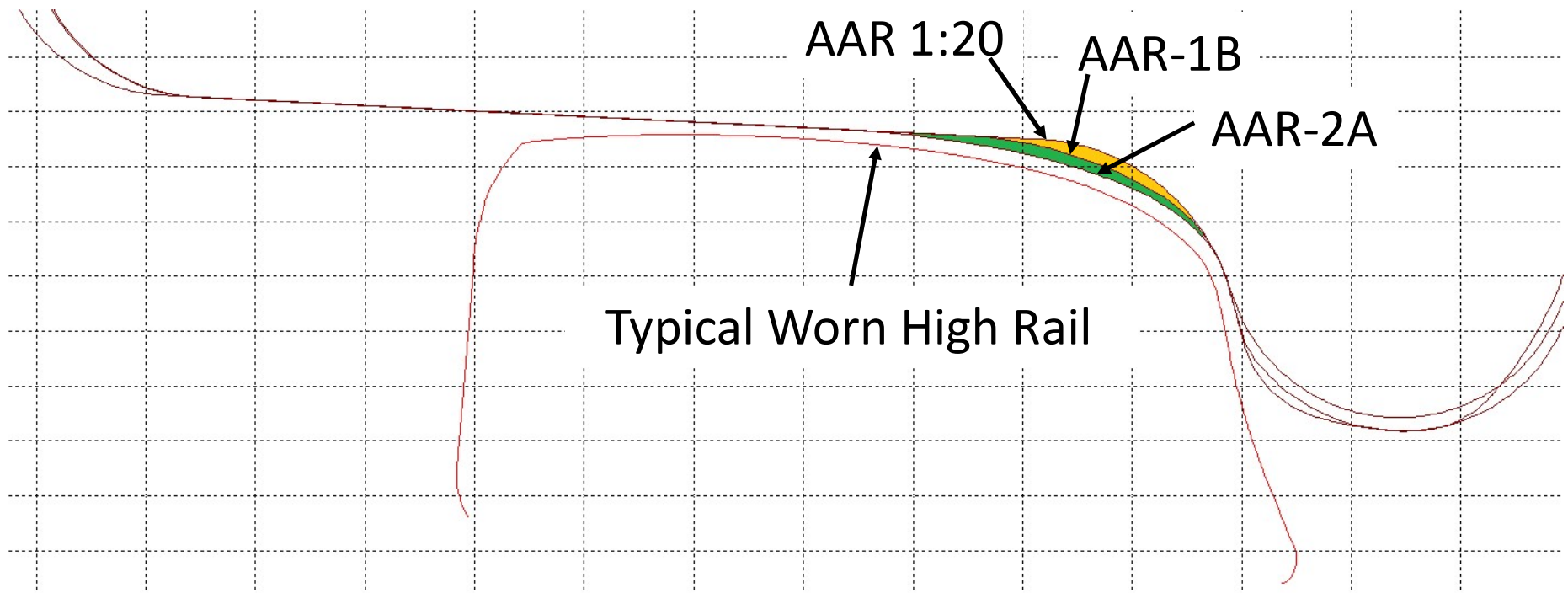


AAR-2A Profile

- **Design based on analysis of 210 pairs of rail profiles and 122 wheelsets**
 - Variety of wear levels, curvatures, car types
- **Original version called TPCI-1A, then SRI-1A**
- **Final version includes a reduction in flange thickness of 1/8 inch**
 - Improve high speed stability
 - Further improve curving performance
- **Wide flange (new, 1.25 inch) and narrow flange (turned, 1.15 inch) versions of the AAR-2A profile available**

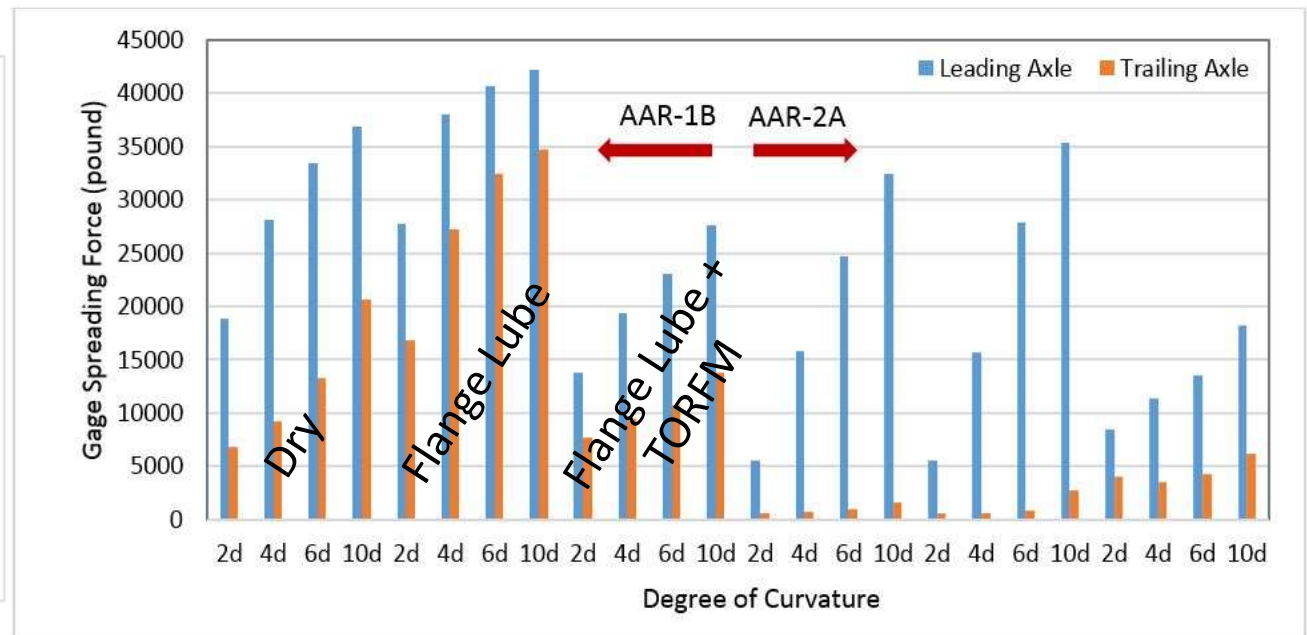
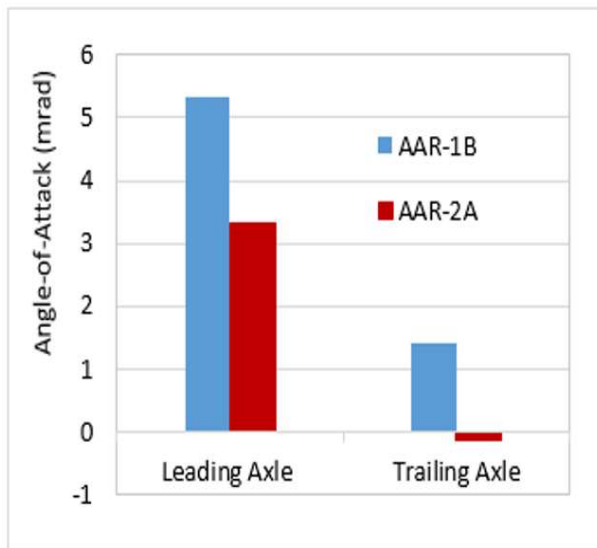


Profile Overlay



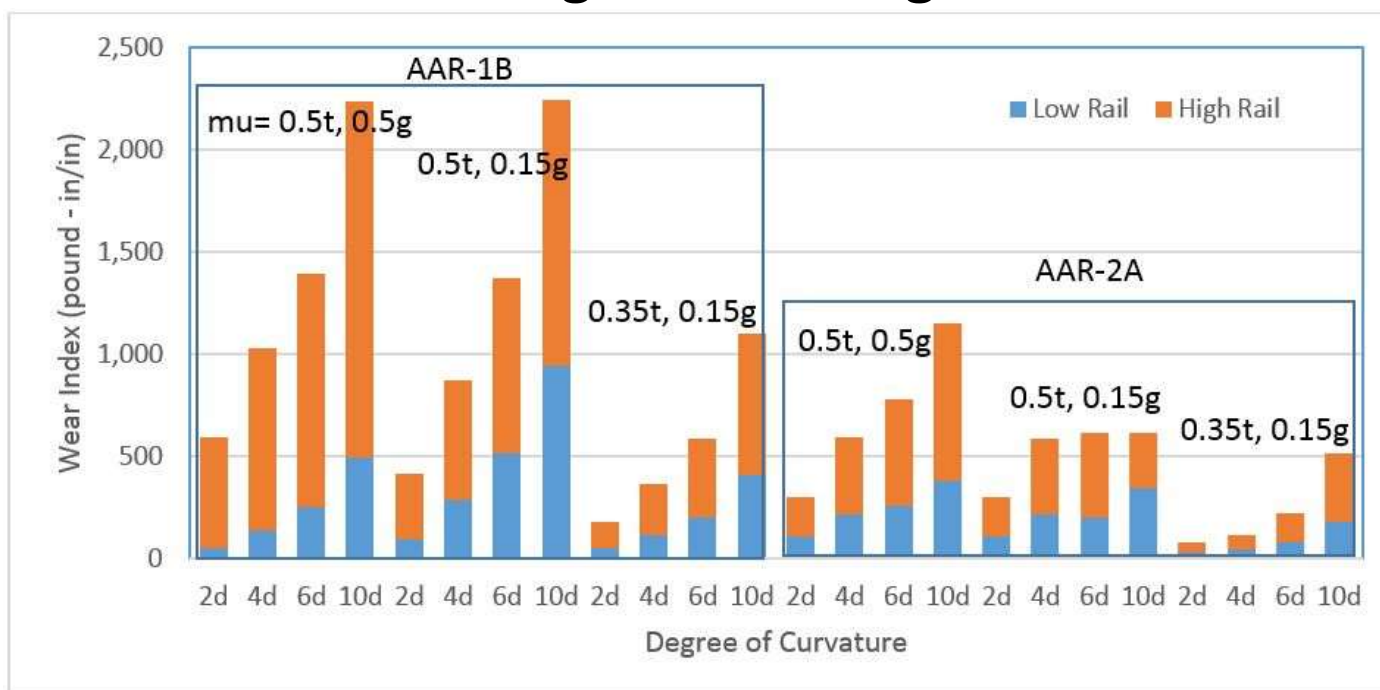
NUCARS® Simulation of AAR-2A

- Reduced angle of attack leads to reduced gage spread force



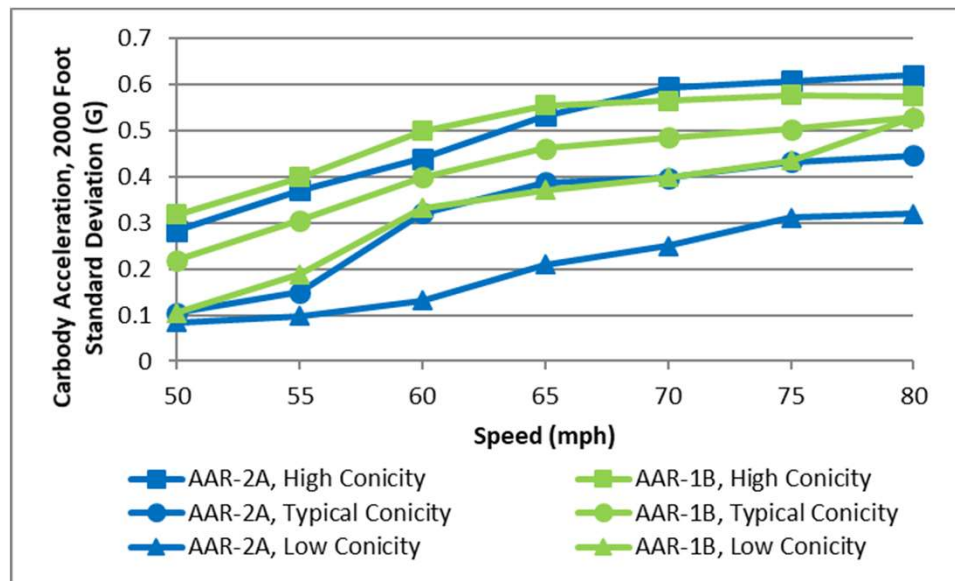
NUCARS® Simulation of AAR-2A

- Reduced wear and rolling contact fatigue



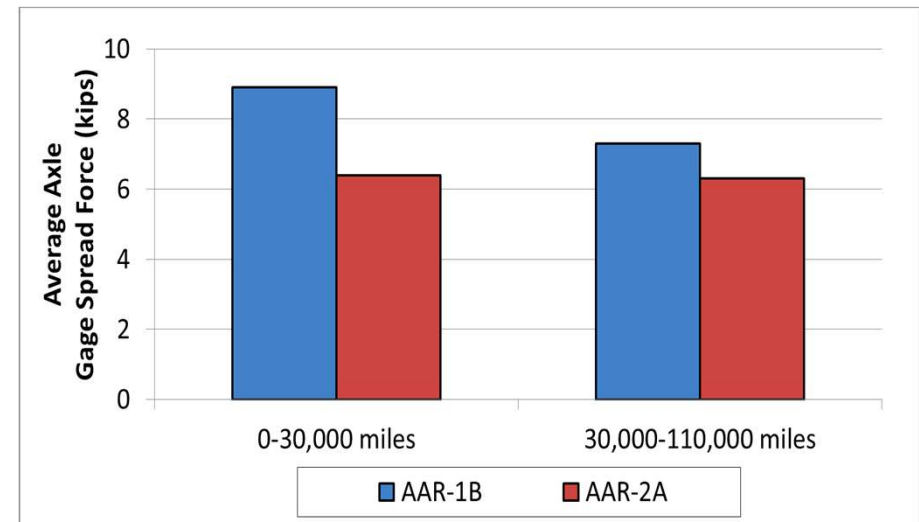
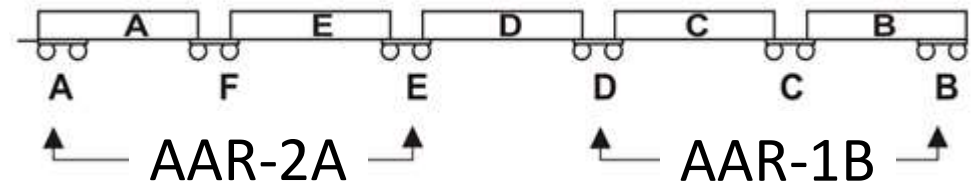
NUCARS® Simulation of AAR-2A 14

- High speed stability similar for worn AAR-1B and worn AAR-2A
 - Measured track geometry and relatively flat rail profile



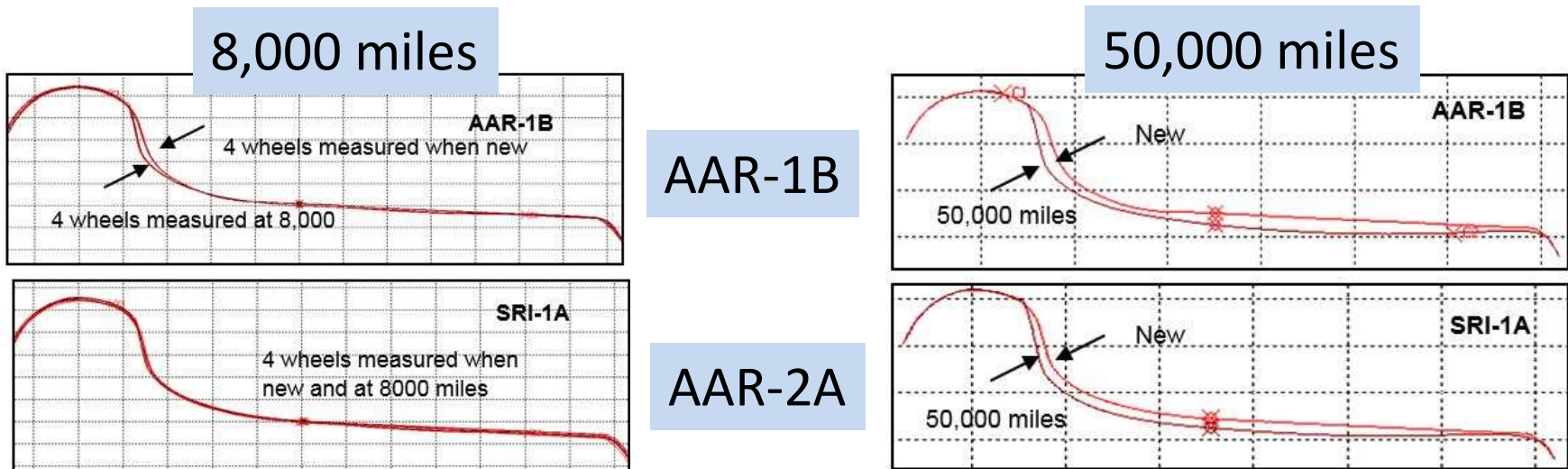
AAR-2A Profile Test #1

- One 5-unit articulated double stack car
- Wheel wear and gage spread force benefits
- Hunting
 - None from 109 wayside passes
 - 1 brief instance measured on-board (original thicker flange version of profile)



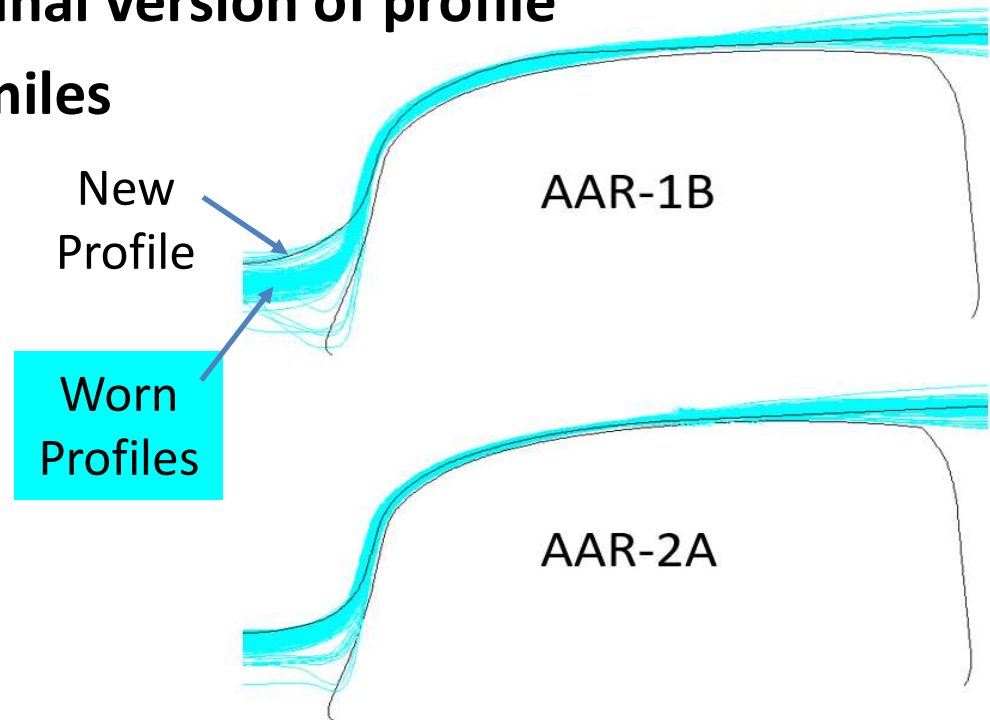
AAR-2A Profile Test #2

- 10 coal cars
- Gage spread force benefits noted up to 25,000 miles of service



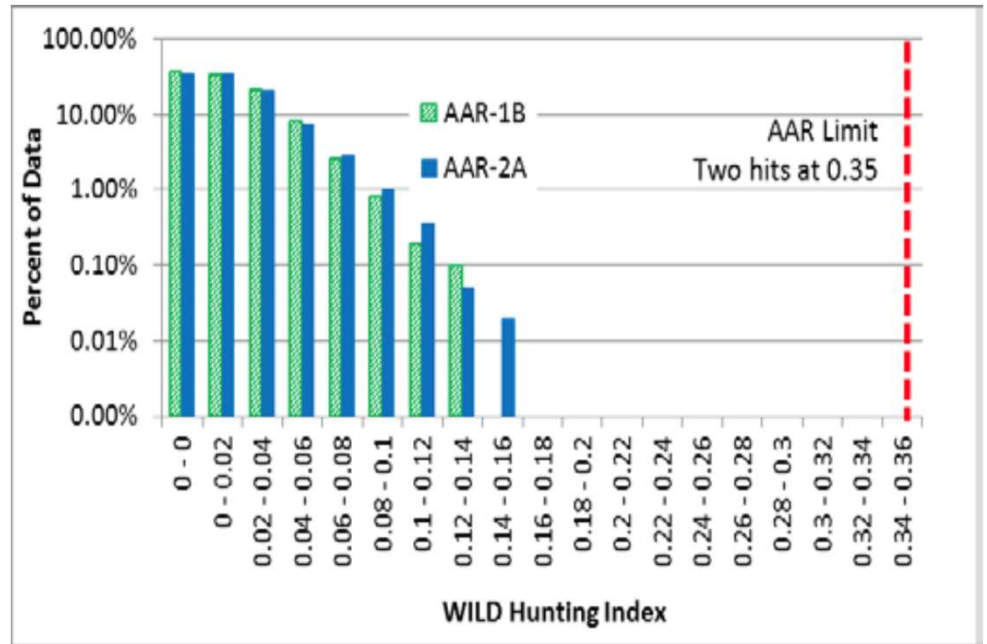
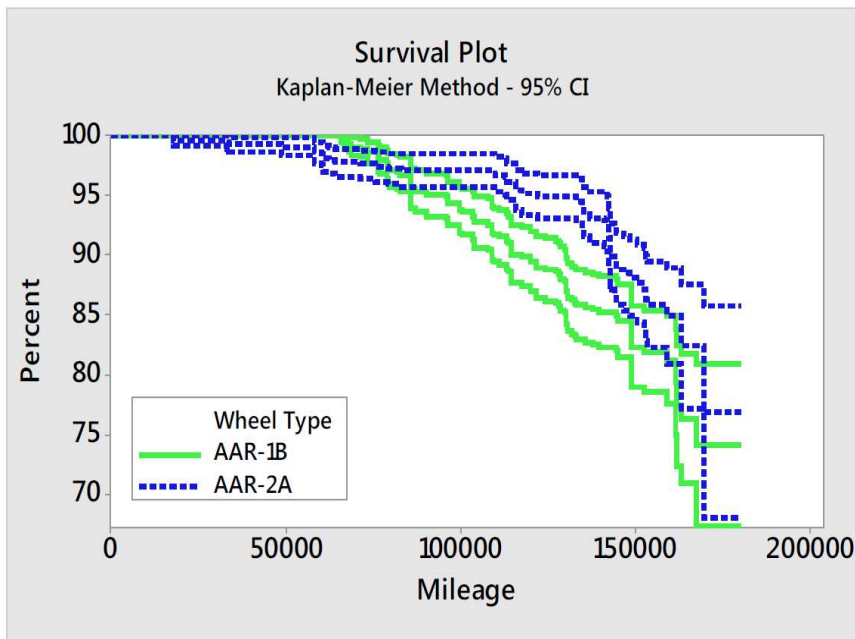
AAR-2A Profile Test #3

- 200 grain hoppers, 2 RRs, final version of profile
- Wear benefits at 115,000 miles
 - 40% less tread wear
 - Lower wear rate for flange thickness
 - Less hollowing and asymmetric wear
 - Flange root shape



AAR-2A Profile Test #3

- Wheelset survival + hunting results



Conclusions

- **AAR-2A designed to be nearly conformal with typical high rail**
 - Flange root shape based on measured worn wheels
 - Rolling resistance, wear, fuel consumption, surface damage
- **75 degree flange angle, 1:20 tread taper**
- **Development similarities to predecessor (AAR-1B)**
- **Analysis, simulation, testing show benefits**
- **AAR currently allows AAR-2A as alternate standard for turned wheels; will begin transition to AAR-2A for new wheels in 2018**

