

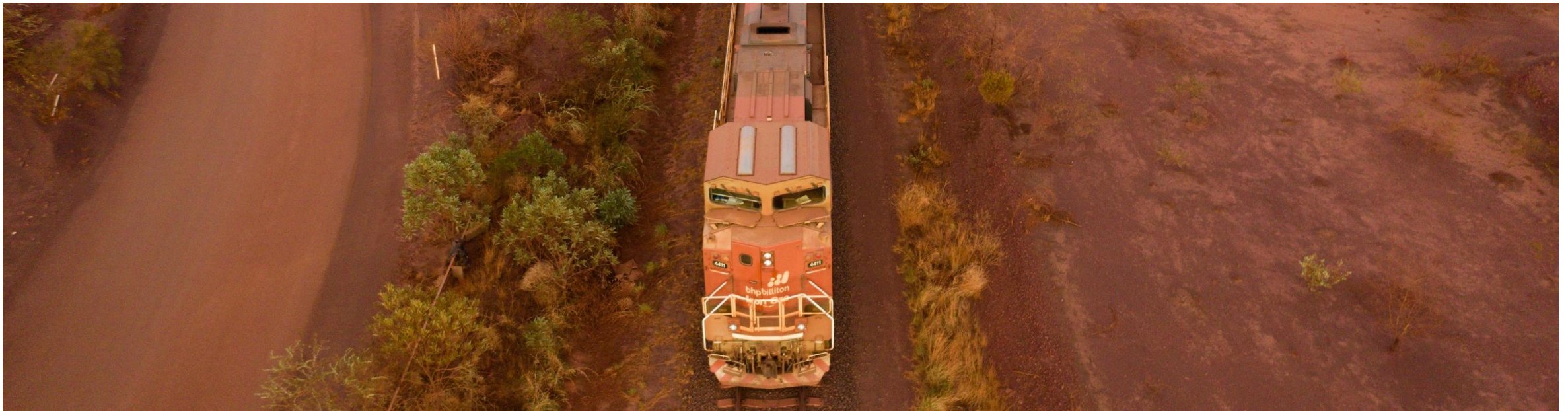


Case study: Turnout performance under heavy haul traffic – challenges and initiatives

Simone Issomura

ICRI Workshop

August 27, 2023 - Rio de Janeiro





Introduction

Simone Issomura MEng

Senior Track and Civil Engineer

BHP

simone.issomura@bhp.com

Simone Issomura was born in Brazil, great-granddaughter of Japanese immigrants. She received her Construction Technician degree in 1999 and Civil Engineering Bachelor's degree in 2004.

She started her railway career at São Paulo Subway's Permanent Way Department in 2006, while studying Quality and Reliability Engineering concurrently, in a specialisation course. After that she wrote a monograph about alternatives to minimise turnout wear as part of a specialisation course in Railway Engineering.

She worked on railways that mixed passenger, general cargo and heavy haul traffic, in areas such as Track Reliability, Turnout Renewals and Corporative Rail Engineering.

Simultaneously she was completing her Master's degree in Transport Engineering where she analysed heavy haul turnout components' performance in her dissertation.

Simone left Brazil as a Senior Engineer and moved to Australia in 2019. She worked supporting the turnout maintenance teams in the Pilbara region, and finally joined BHP's Rail Engineering Track and Civil team in 2021.

Altogether Simone has had 17 years of experience in railways, in Brazil and Australia. She is passionate about combining theory and practice to develop engineering initiatives that improve safety, efficiency, productivity, cost-benefit and reliability.

1. Objective

Objective

To present some challenges and initiatives related to turnout performance under heavy haul traffic.

2. Introduction

The BHP Network



The BHP Network



BHP Turnouts

Features:

Gauge = 1435mm

Axle load = 40t

Cargo = iron ore

Diverge design speed:

- 1:10 – 30km/h
- 1:15 – 35km/h
- 1:20 – 65km/h

BHP Turnouts

Features:

Gauge = 1435mm

Axle load = 40t

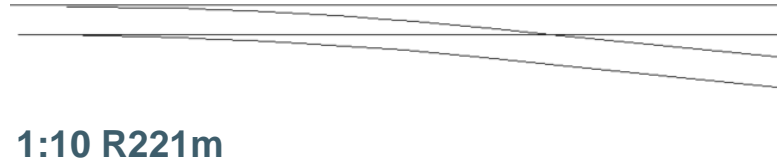
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Turnout design:

- Rate



BHP Turnouts

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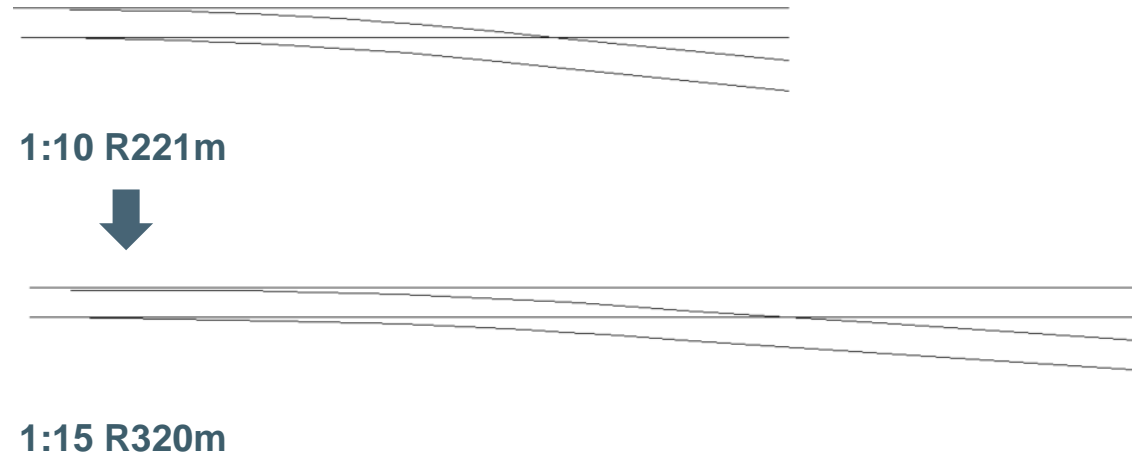
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BHP Turnouts

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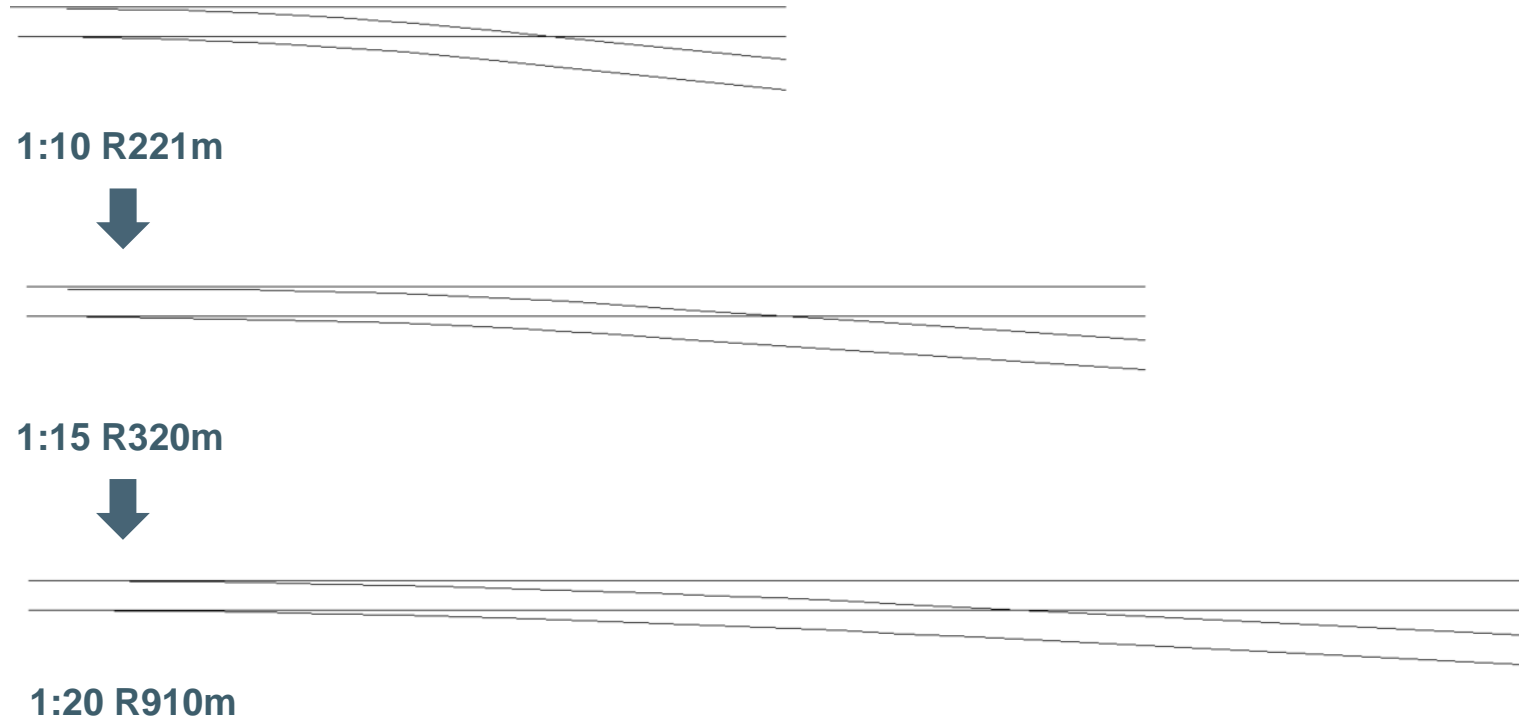
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BHP Turnouts

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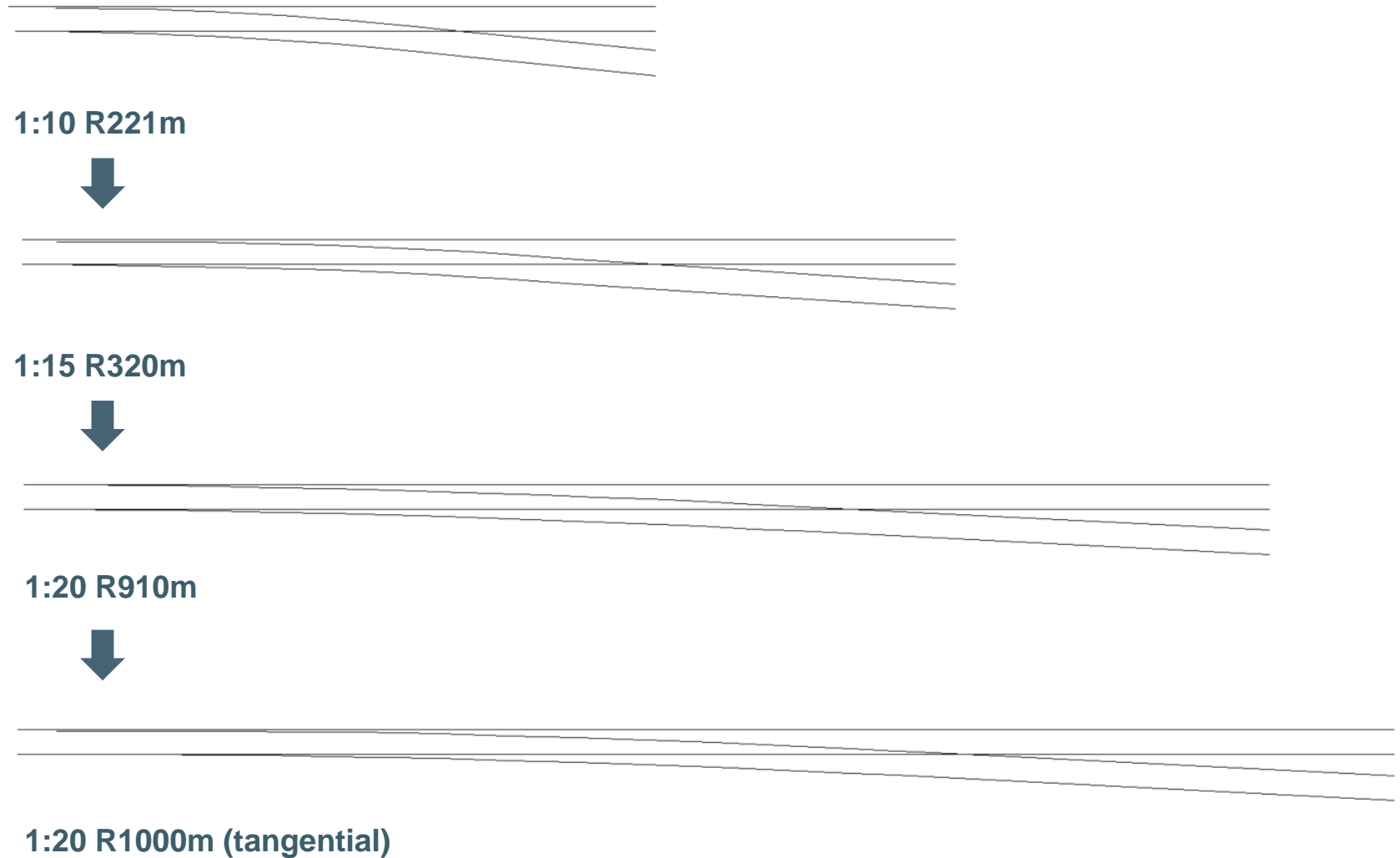
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BHP Turnouts

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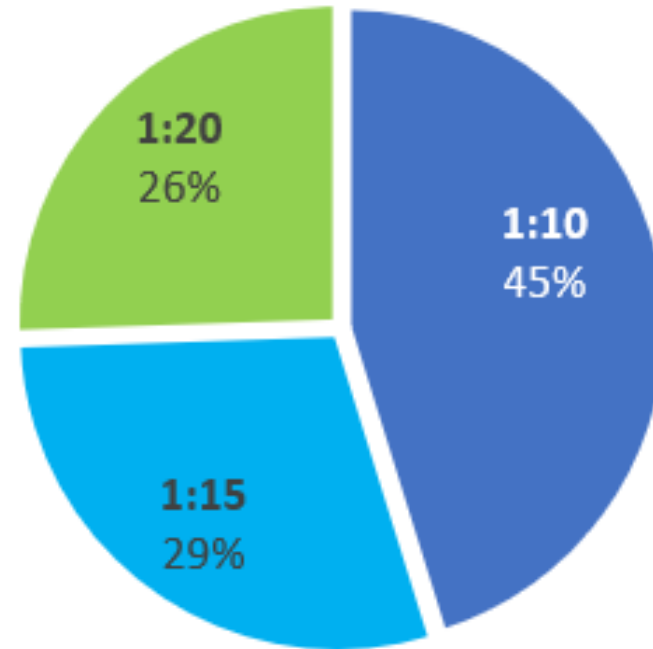
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BHP Turnouts

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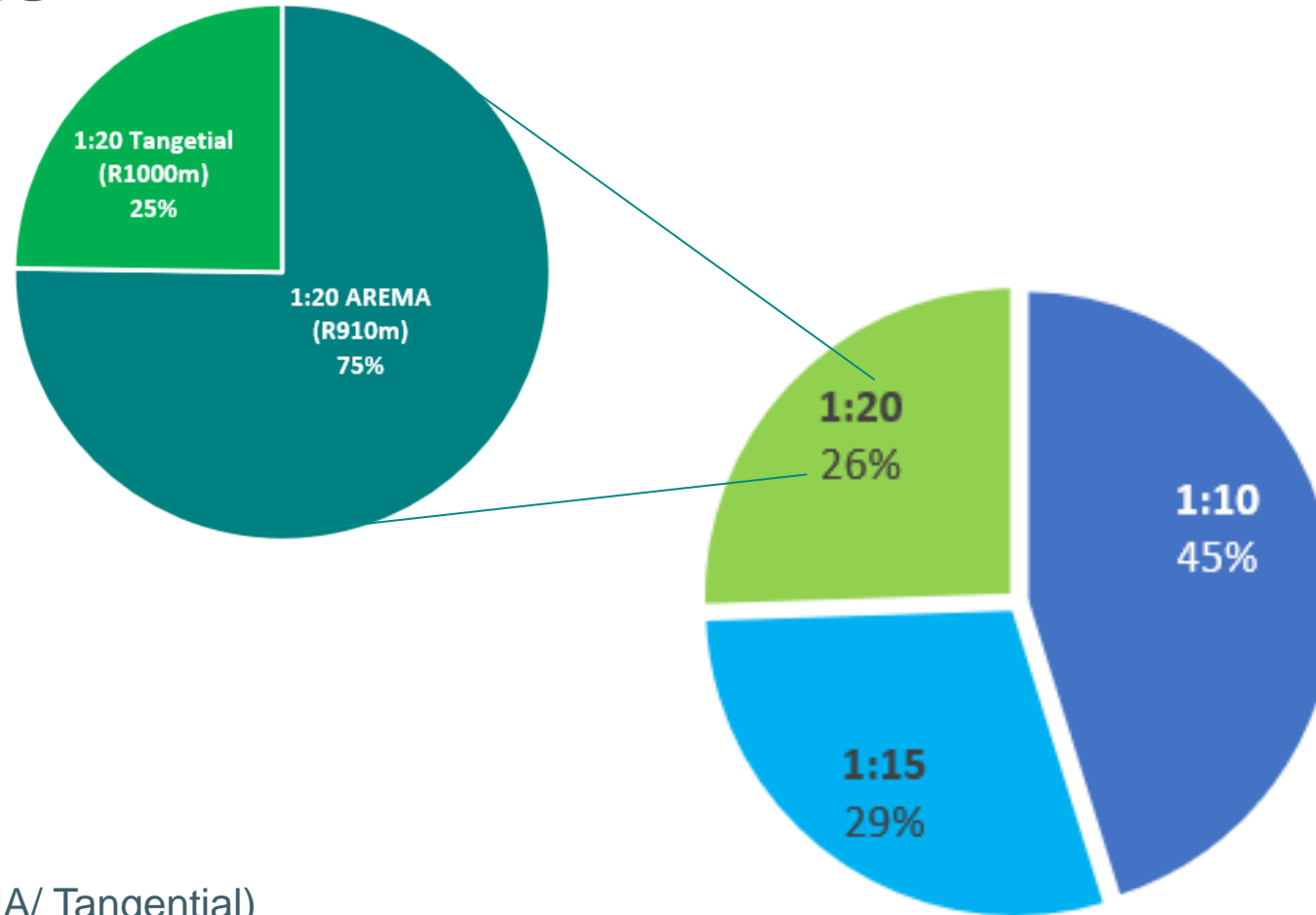
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Turnout design:

- Rate
- Geometry (AREMA/ Tangential)



BHP Turnouts

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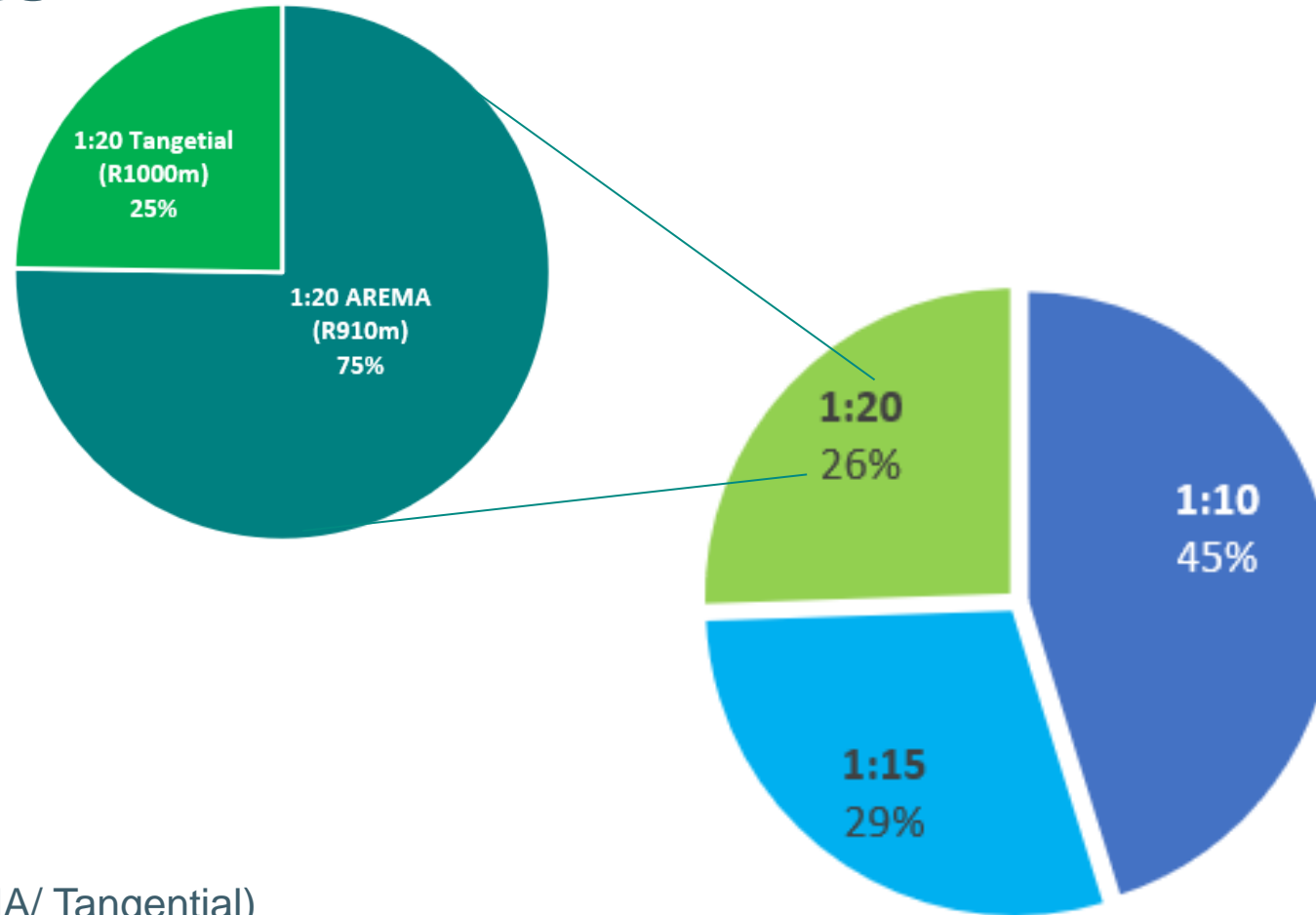
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BHP Turnouts

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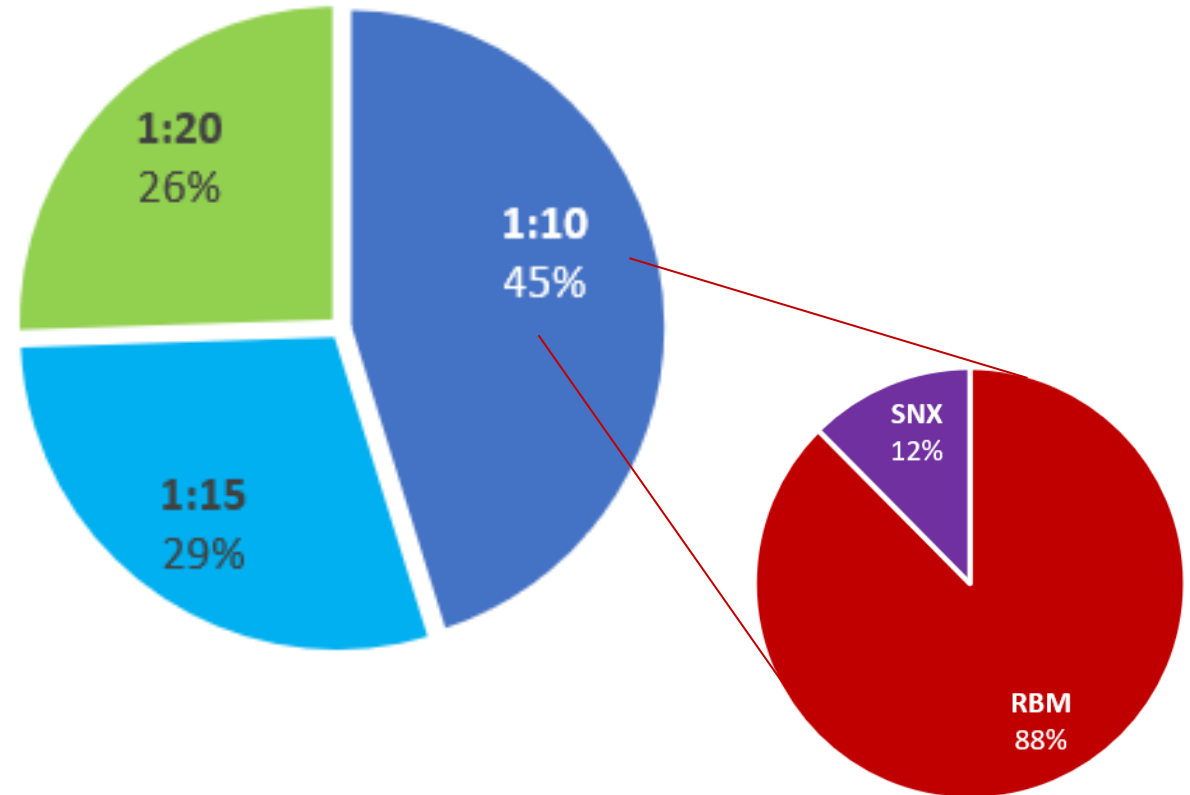
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BHP Turnouts

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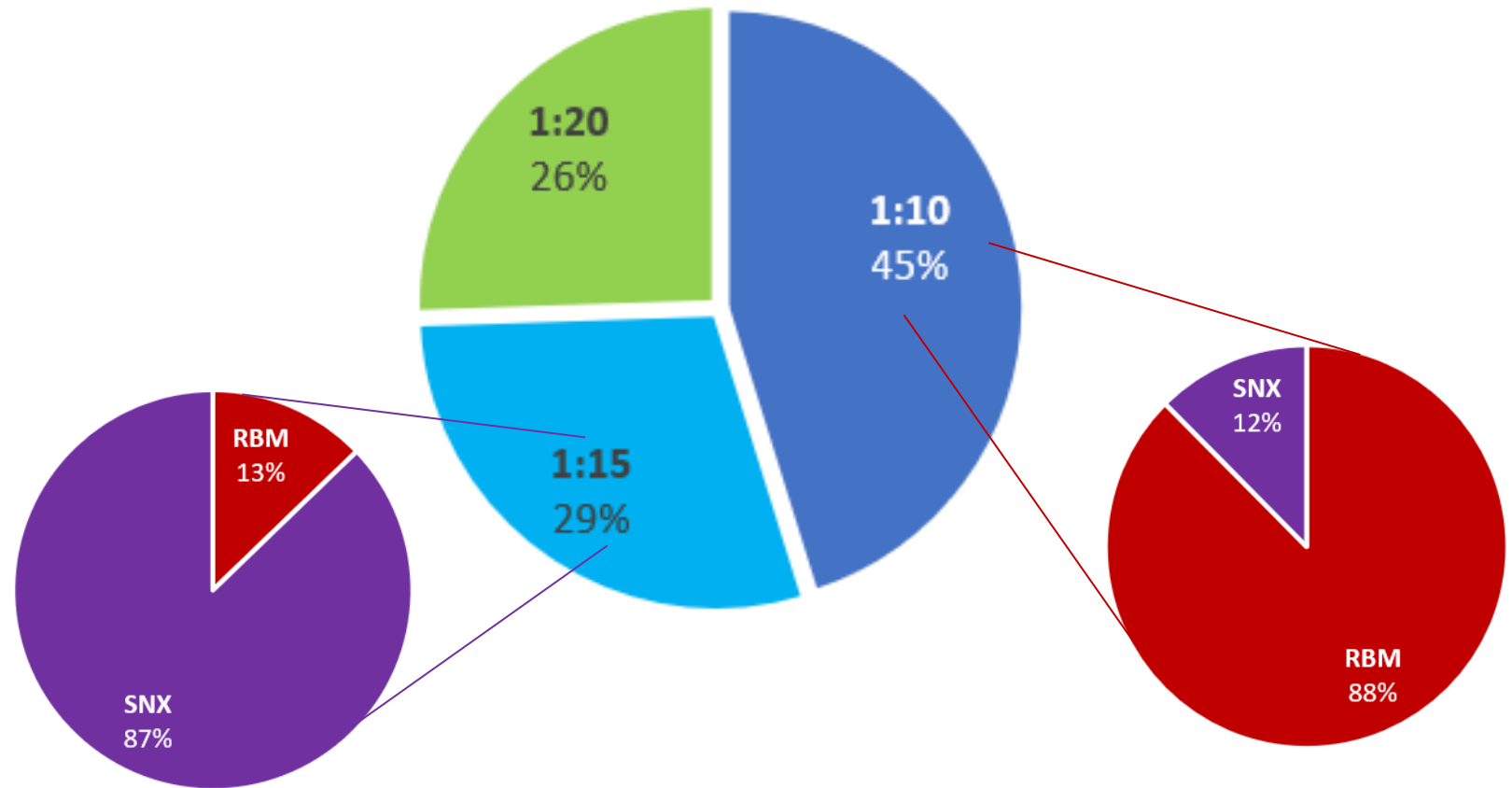
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Turnout Design:

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BHP Turnouts

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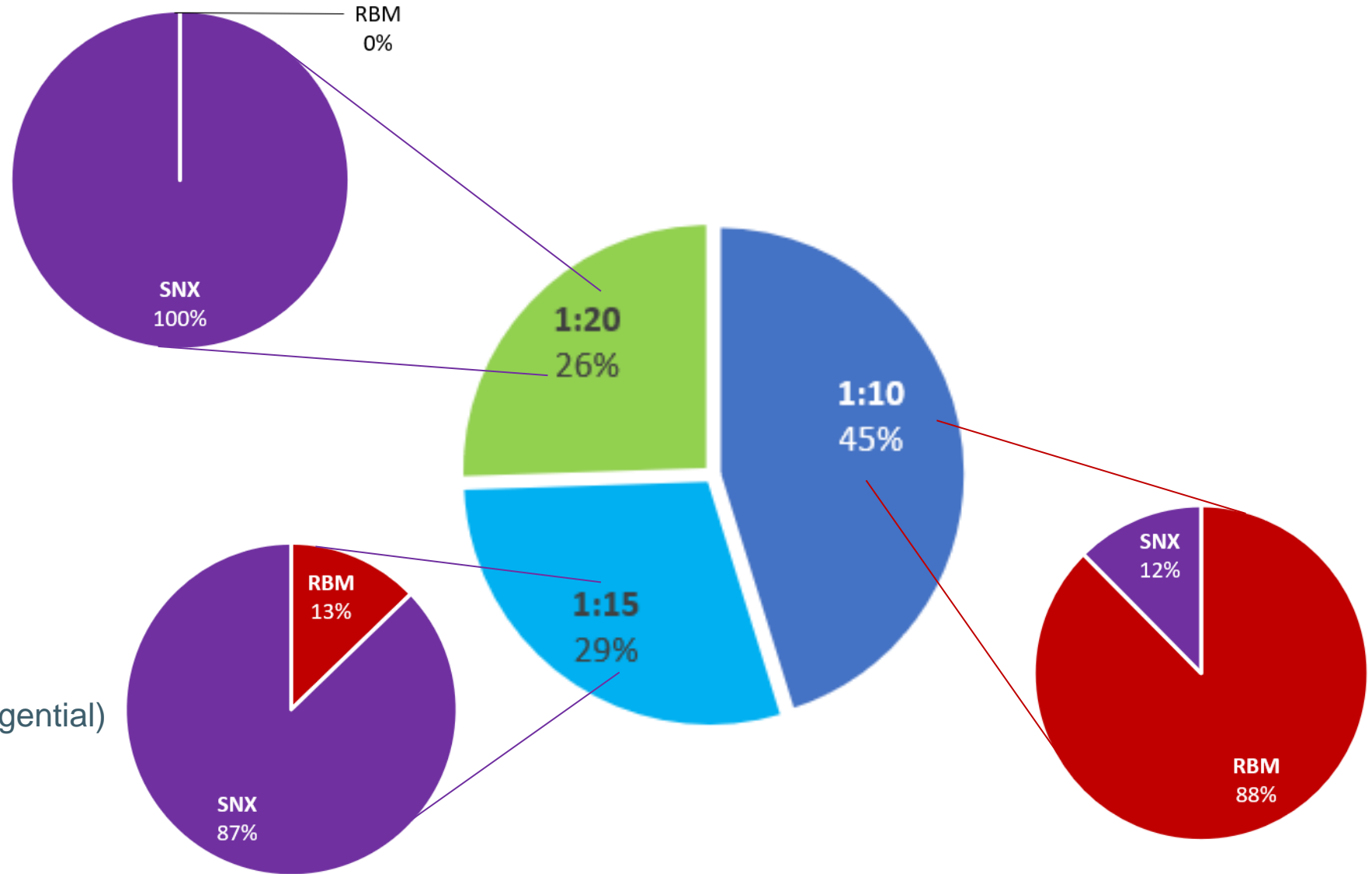
Cargo = iron ore

Diverge Speed:

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- 1:20 – 65km/h

Turnout design:

- Rate
- Geometry (AREMA/ Tangential)
- Frogs



3. Challenges

Turnouts performance

Wear

Turnouts performance

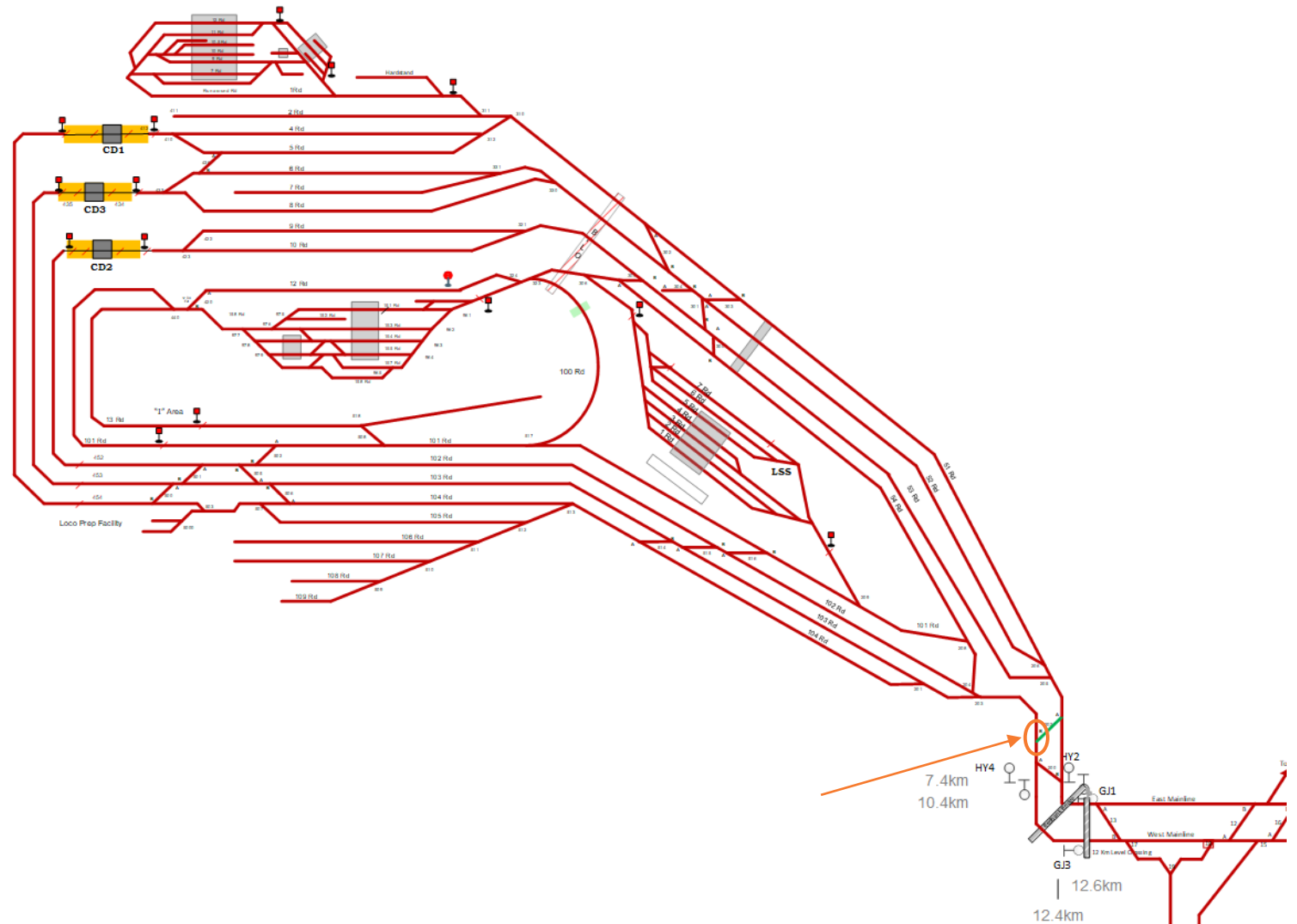
Wear

Example: 1:15 AREMA curved blade

Install date: 13/03/2023

Replace date: 16/07/2023

Life in service: 125 days



Turnouts performance

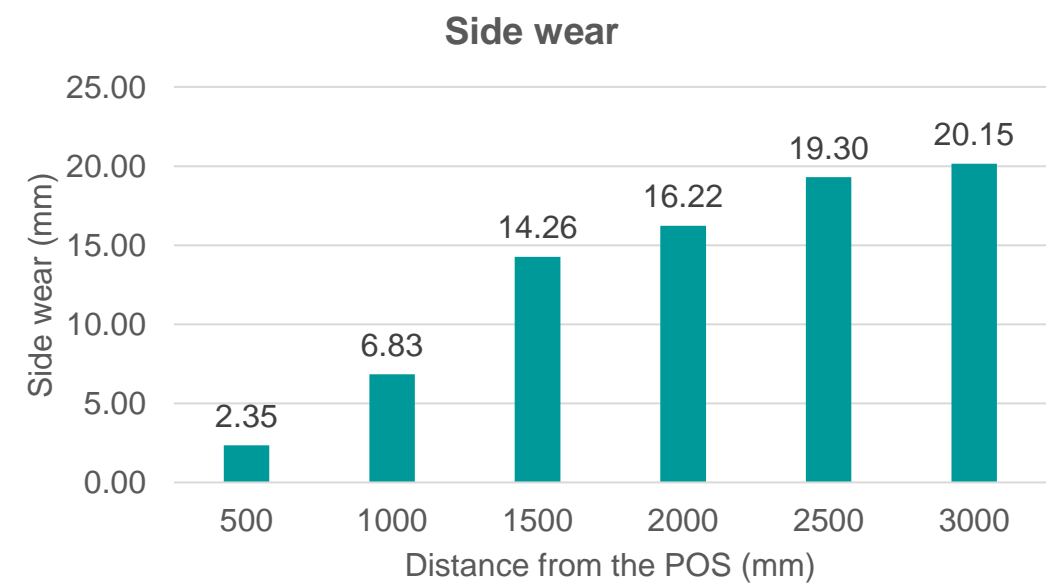
Wear

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Turnouts performance

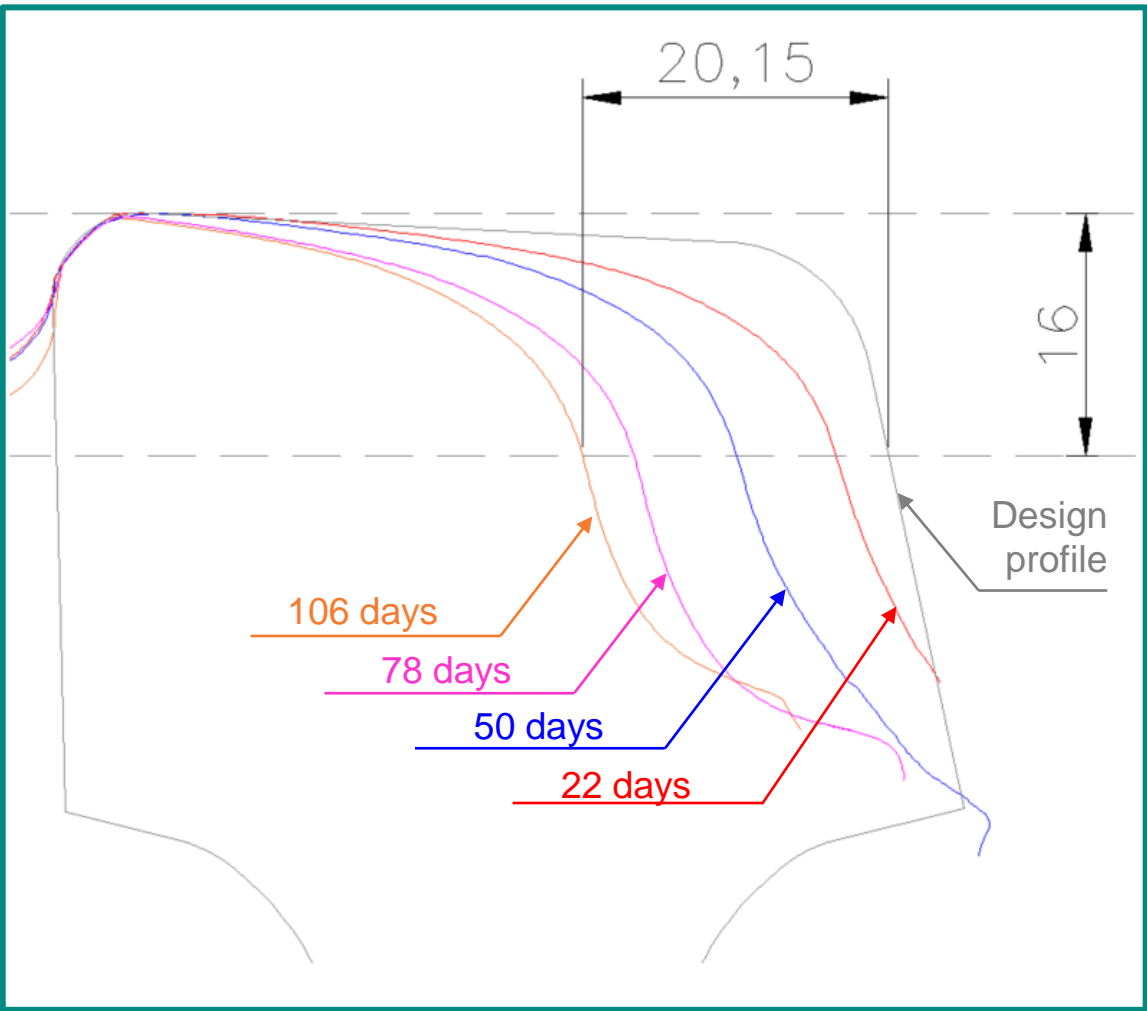
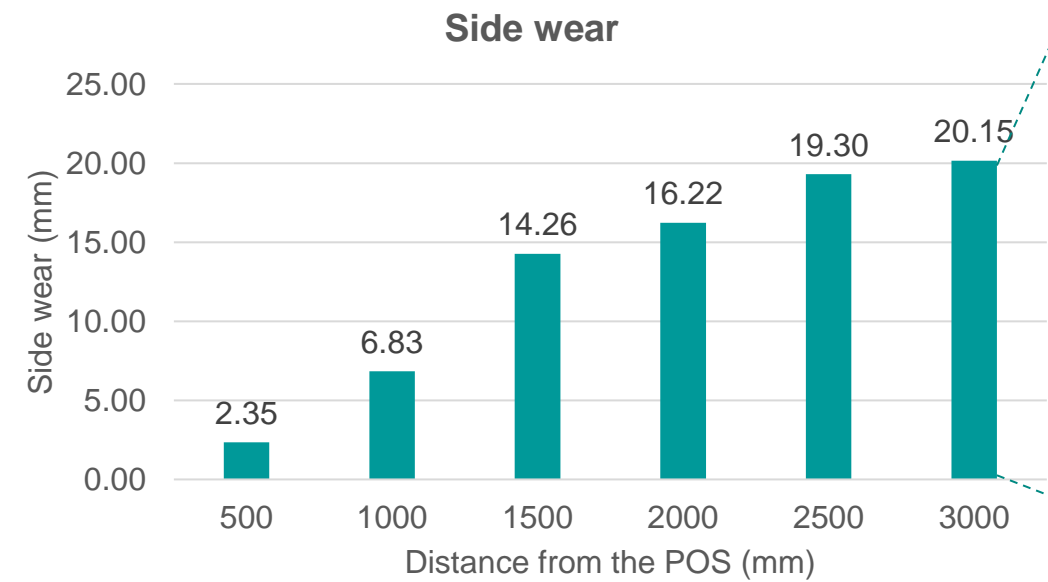
Wear

Example: 1:15 AREMA curved blade

Install date: 13/03/2023

Replace date: 16/07/2023

Life in service: 125 days



1:15 turnout – curved blade – 3000mm from POS

Turnouts performance

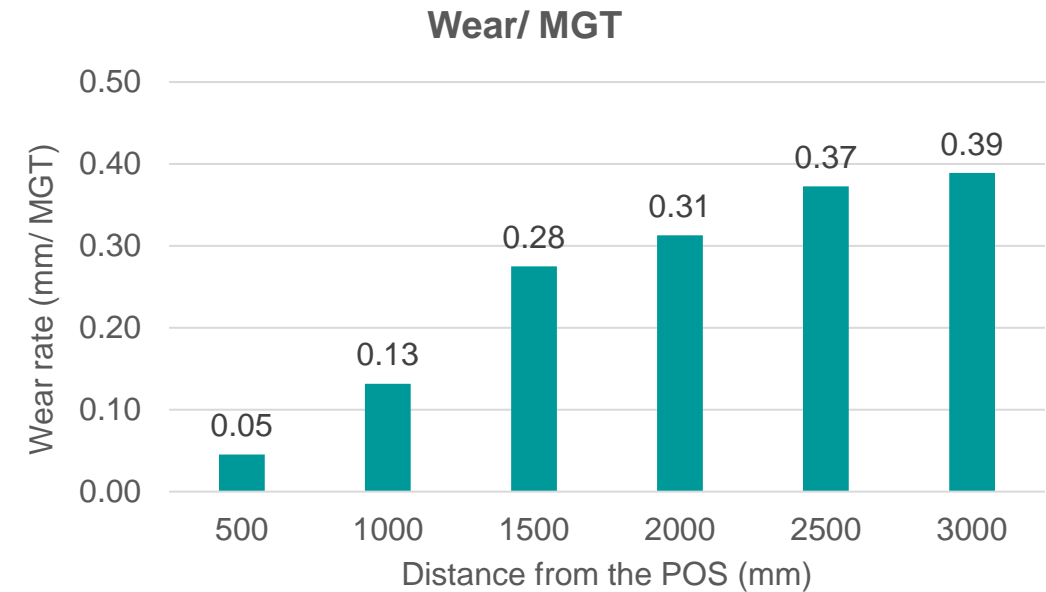
Wear

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Turnouts performance

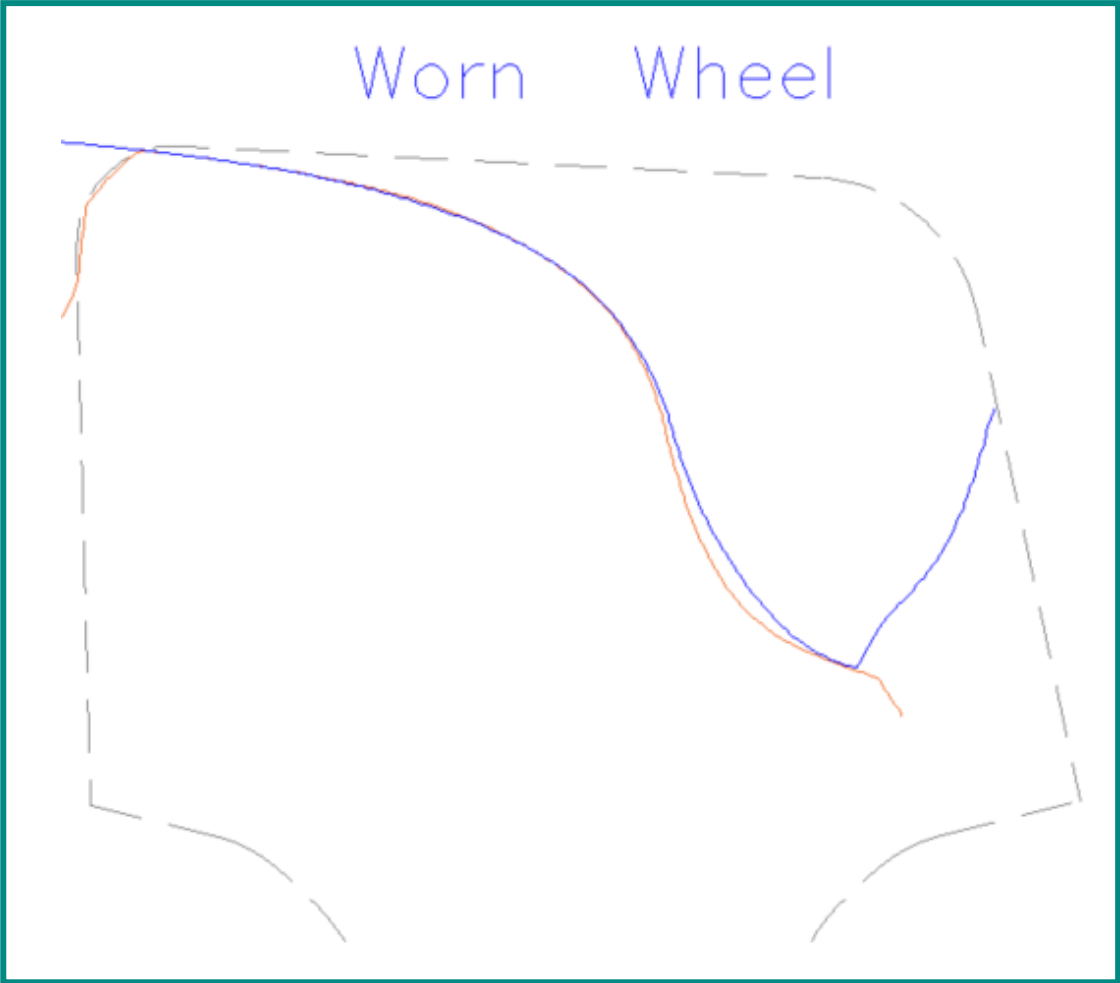
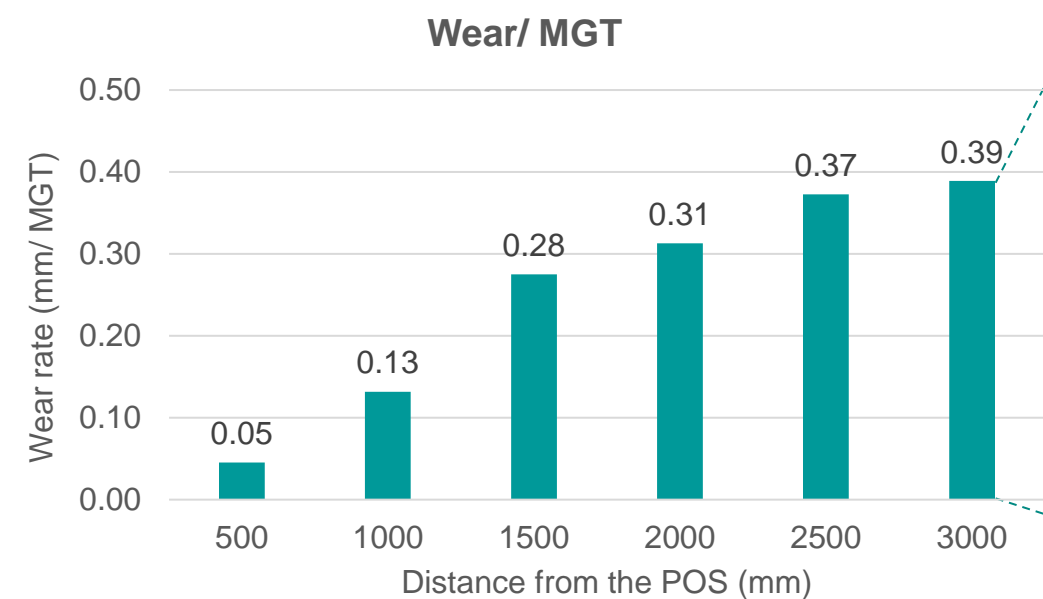
Wear

Example: 1:15 AREMA curved blade

Install date: 13/03/2023

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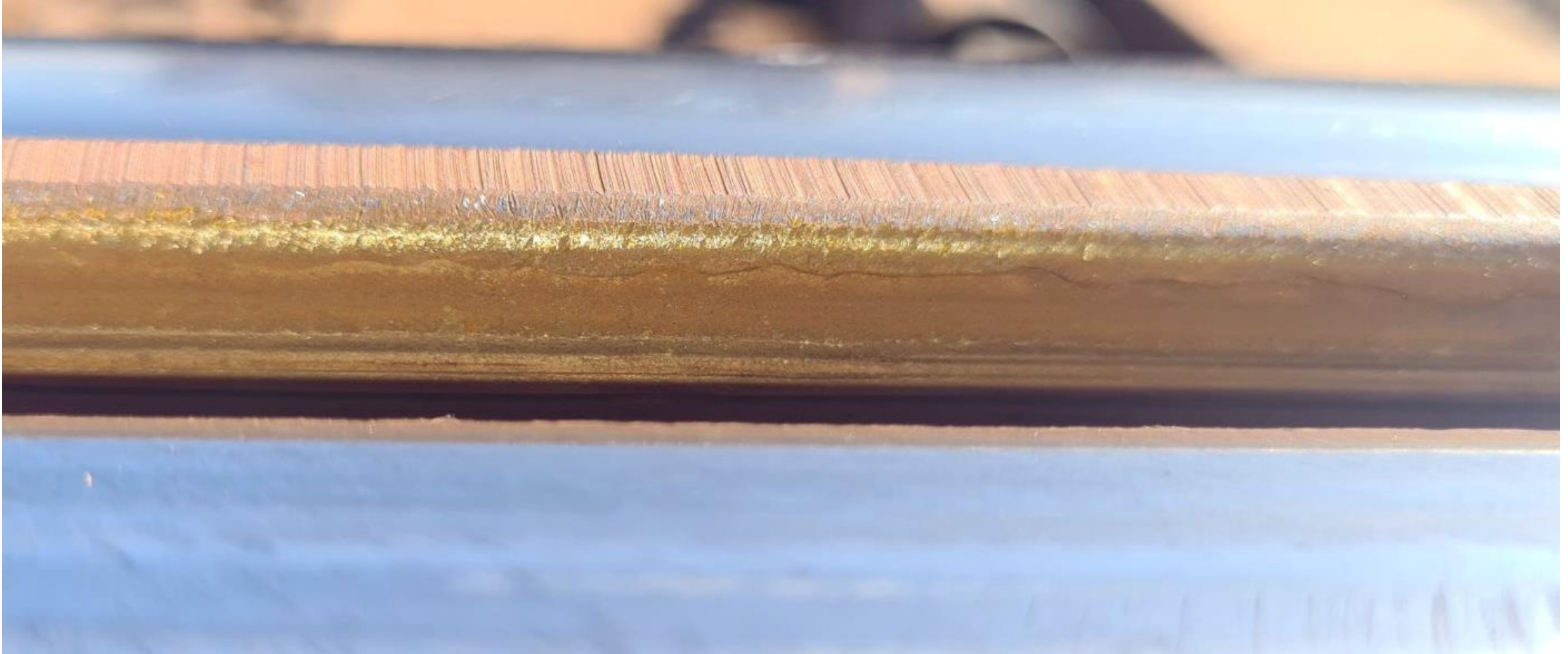
Life in service: 125 days



1:15 turnout – curved blade – 3000mm from POS and a worn wheel

Turnouts performance

Switch blade defects – Field Side Cracking (FSC)



FSC – Initial stages

Turnouts performance

Switch blade defects – Field Side Cracking (FSC)

Different depths



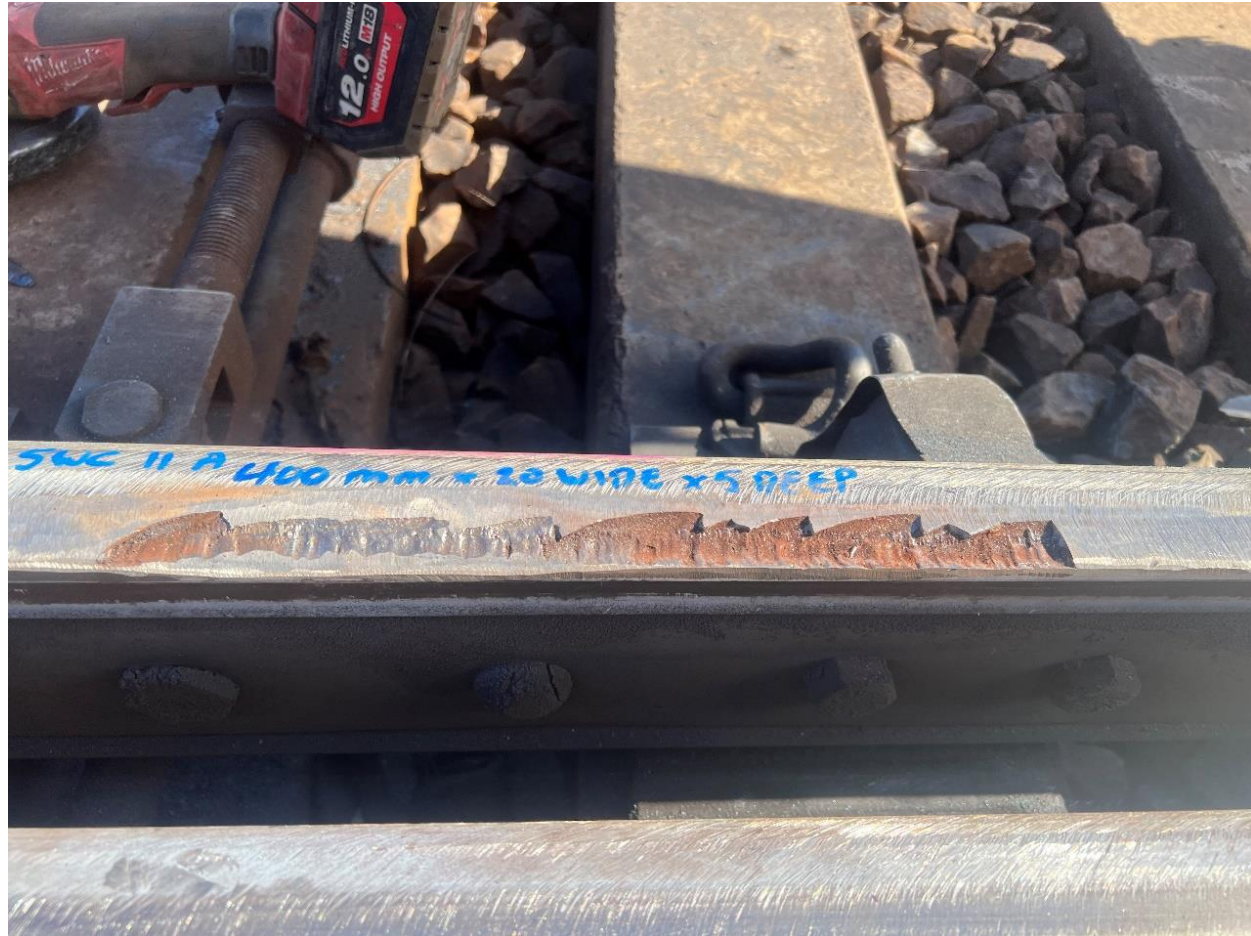
Turnouts performance

Switch blade defects – Field Side Cracking (FSC)



Turnouts performance

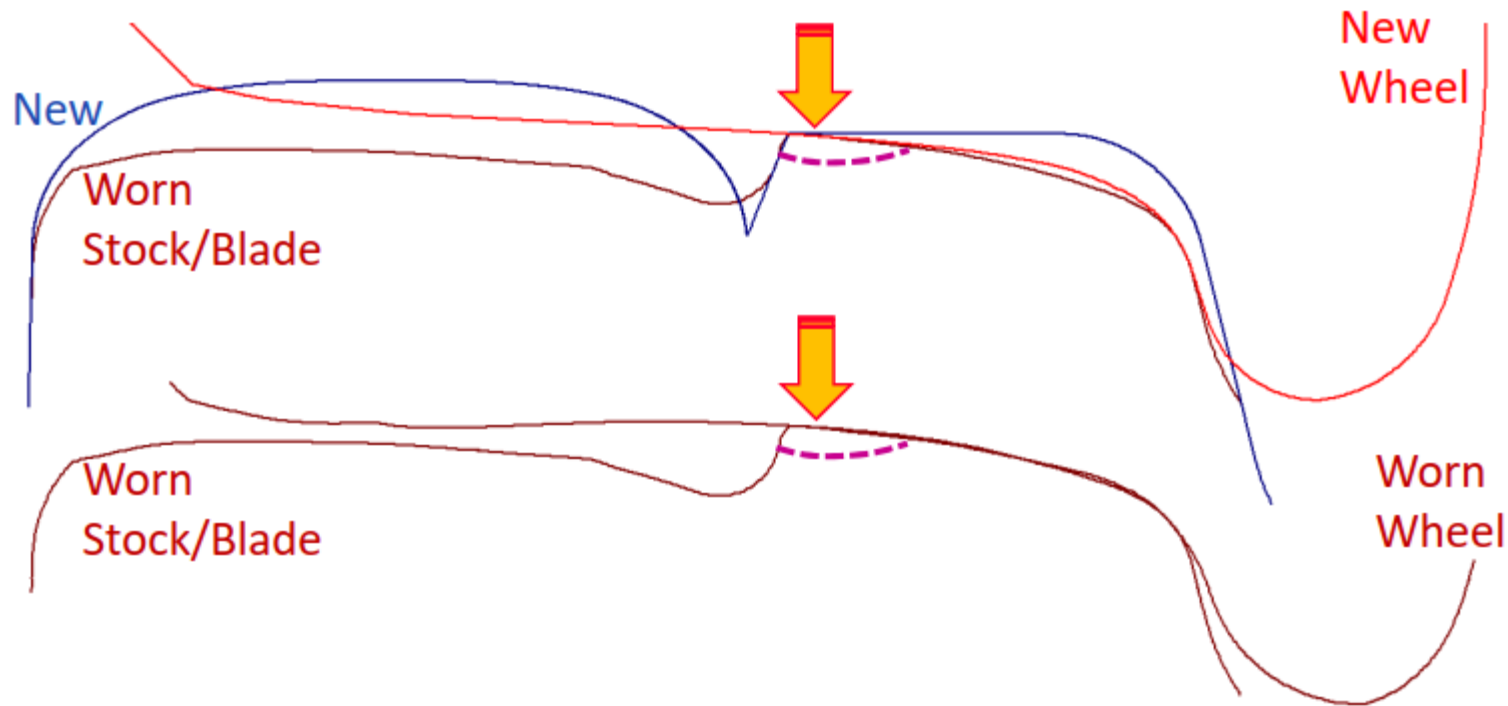
Switch blade defects – Field Side Cracking (FSC)



Turnouts performance

Findings

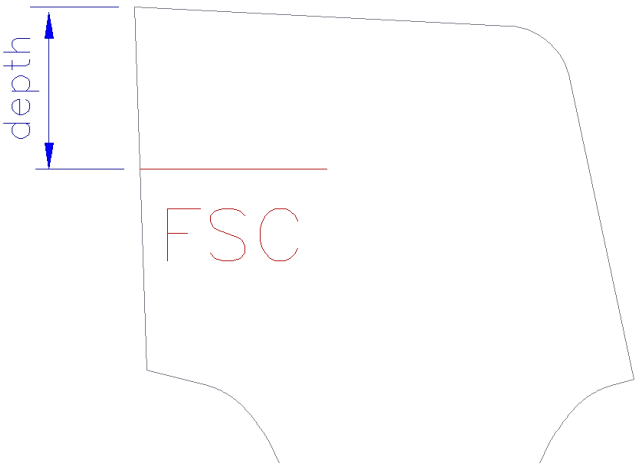
The new and less worn wheels contact sits on top of the field side edge of blade, causing extreme contact stresses and subsurface shear stresses.



Source: WELSBY and PUN (2021)

Turnouts performance

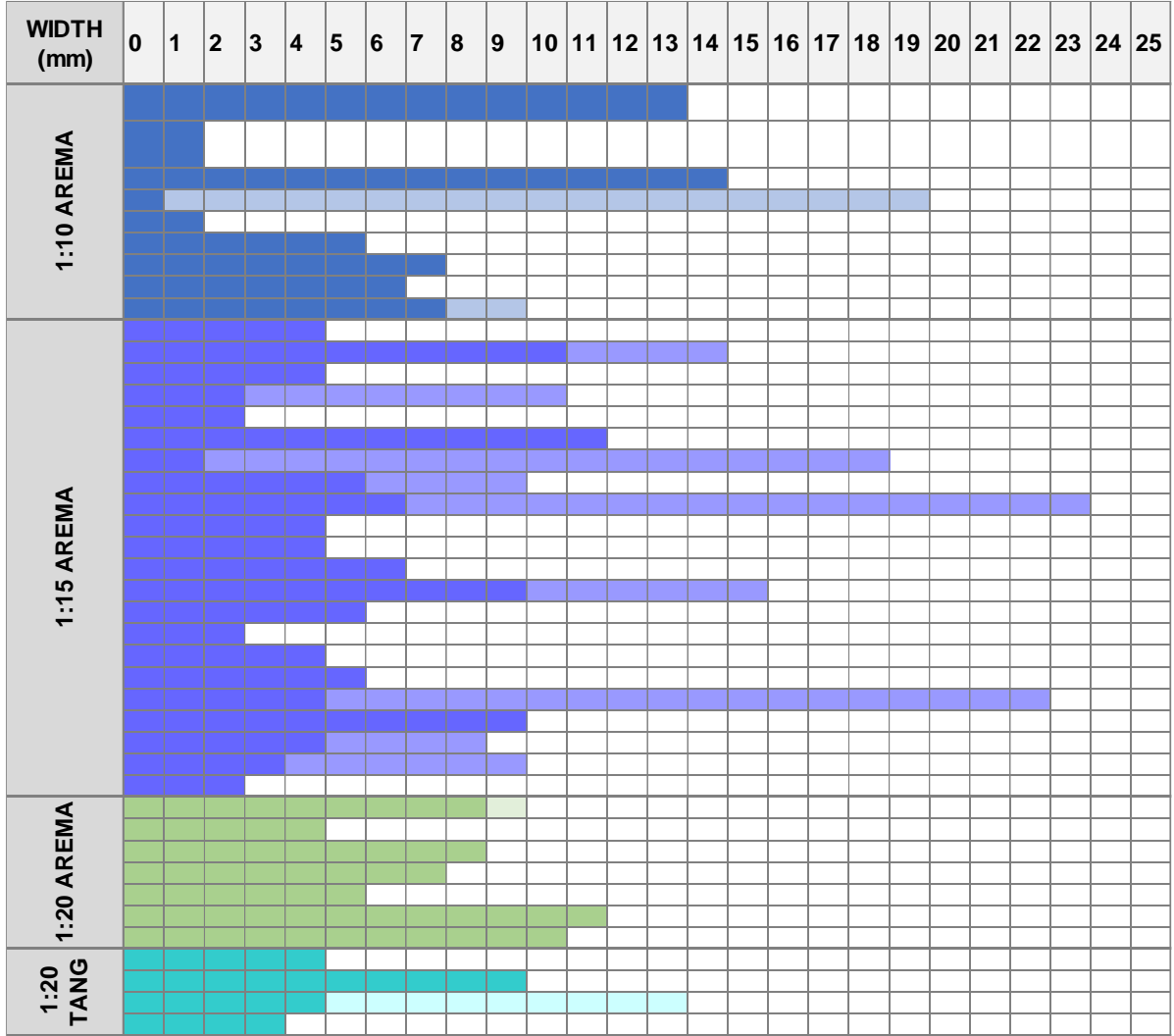
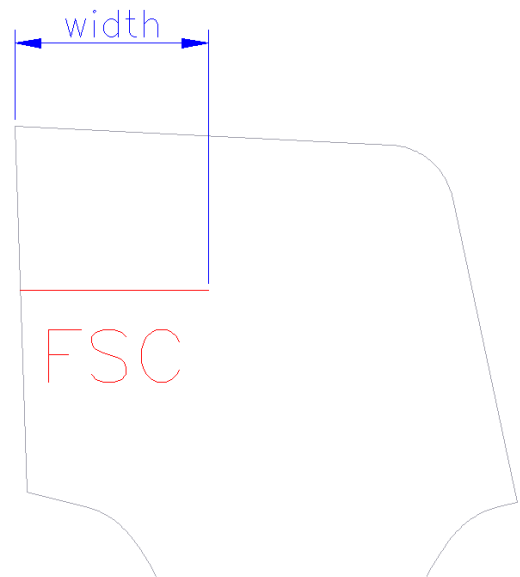
FSC development – depth



DEPTH (mm)	1:10 AREMA				1:15 AREMA												1:20 AREMA				1:20 TANG																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
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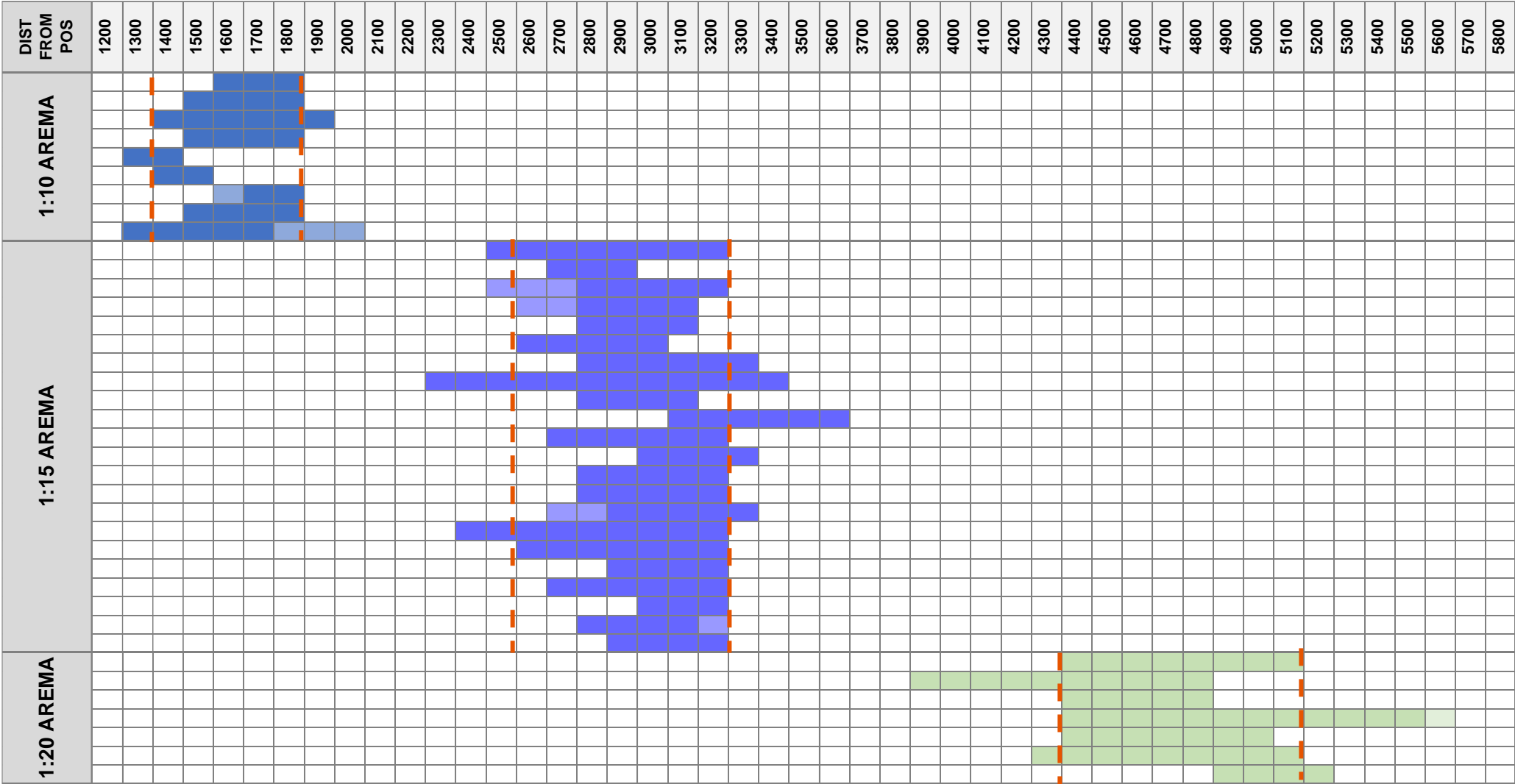
Turnouts performance

FSC development – width



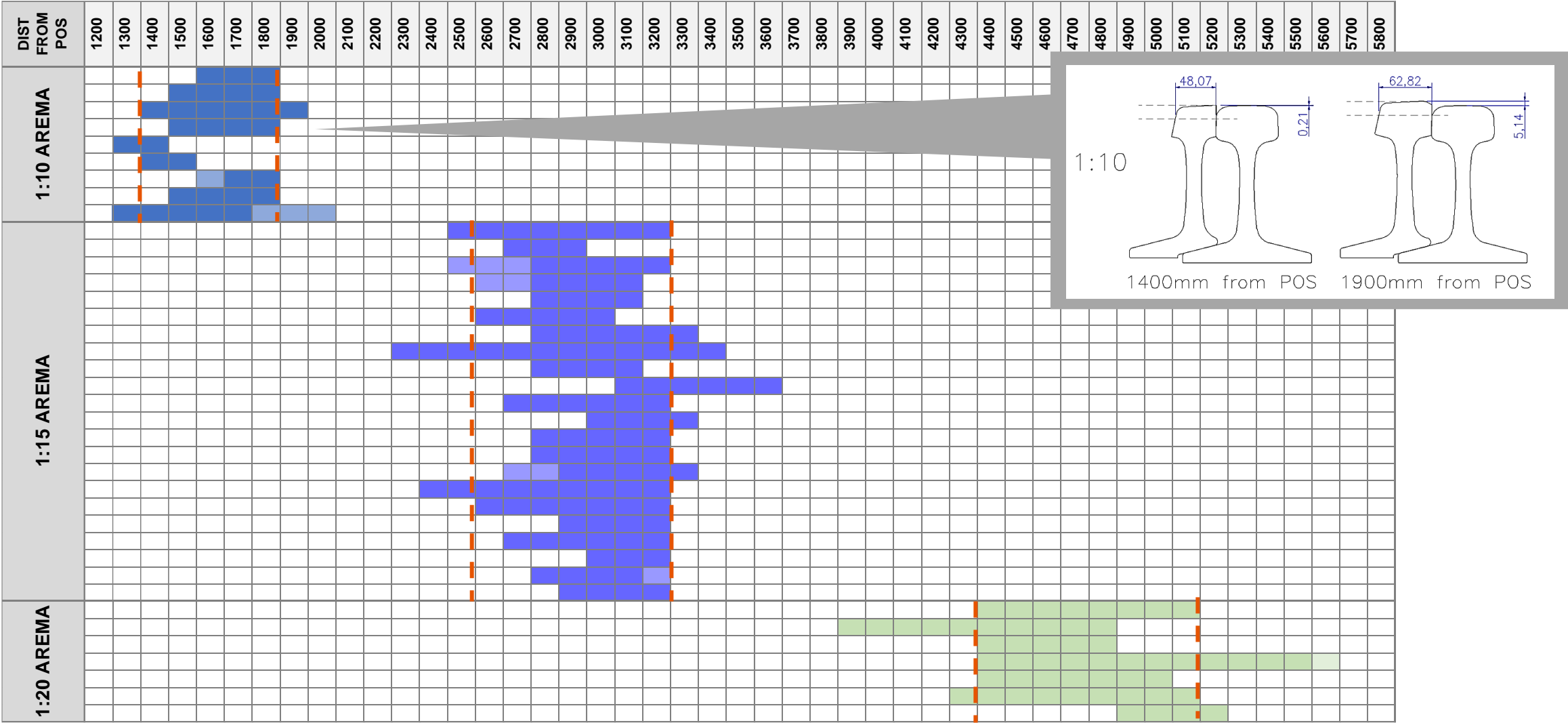
Turnouts performance

FSC development – Length



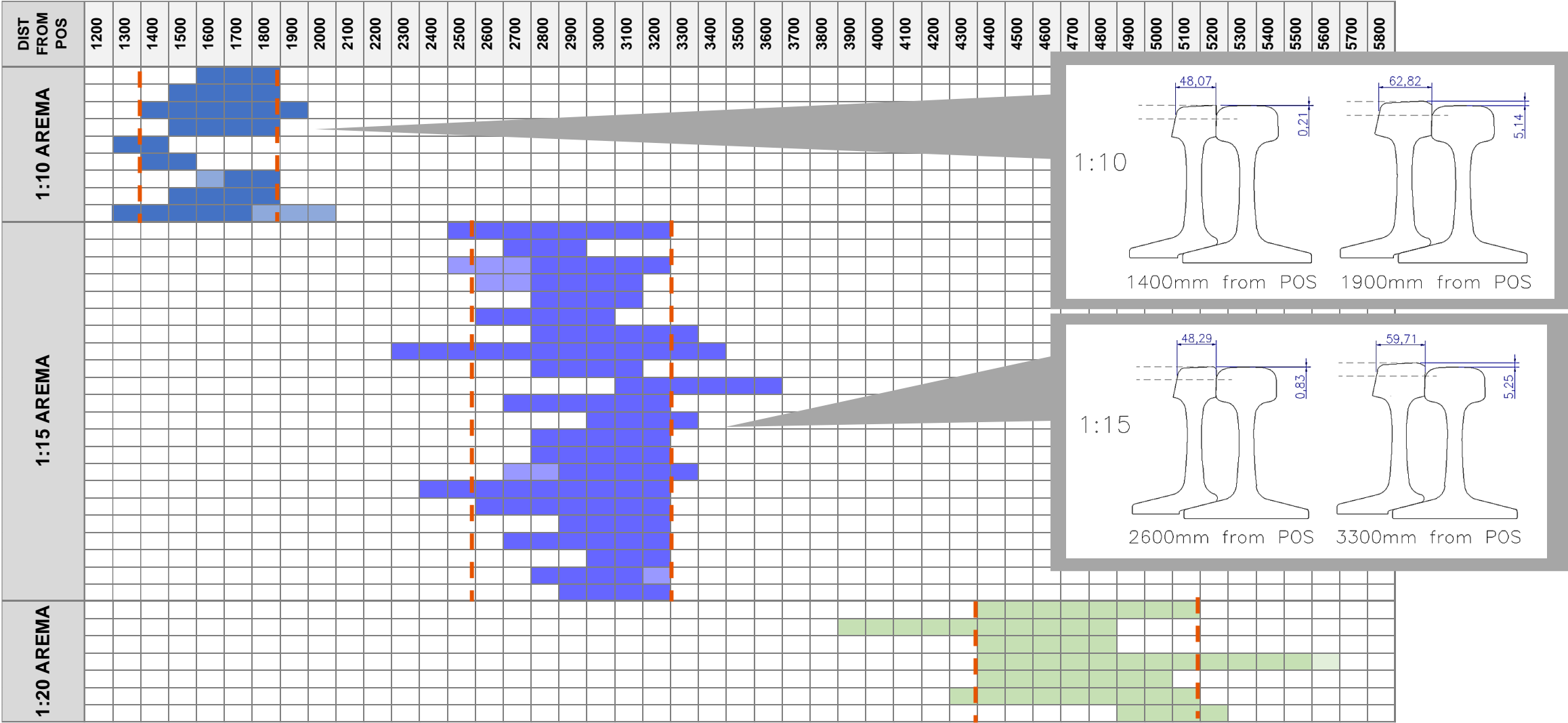
Turnouts performance

FSC development – Length



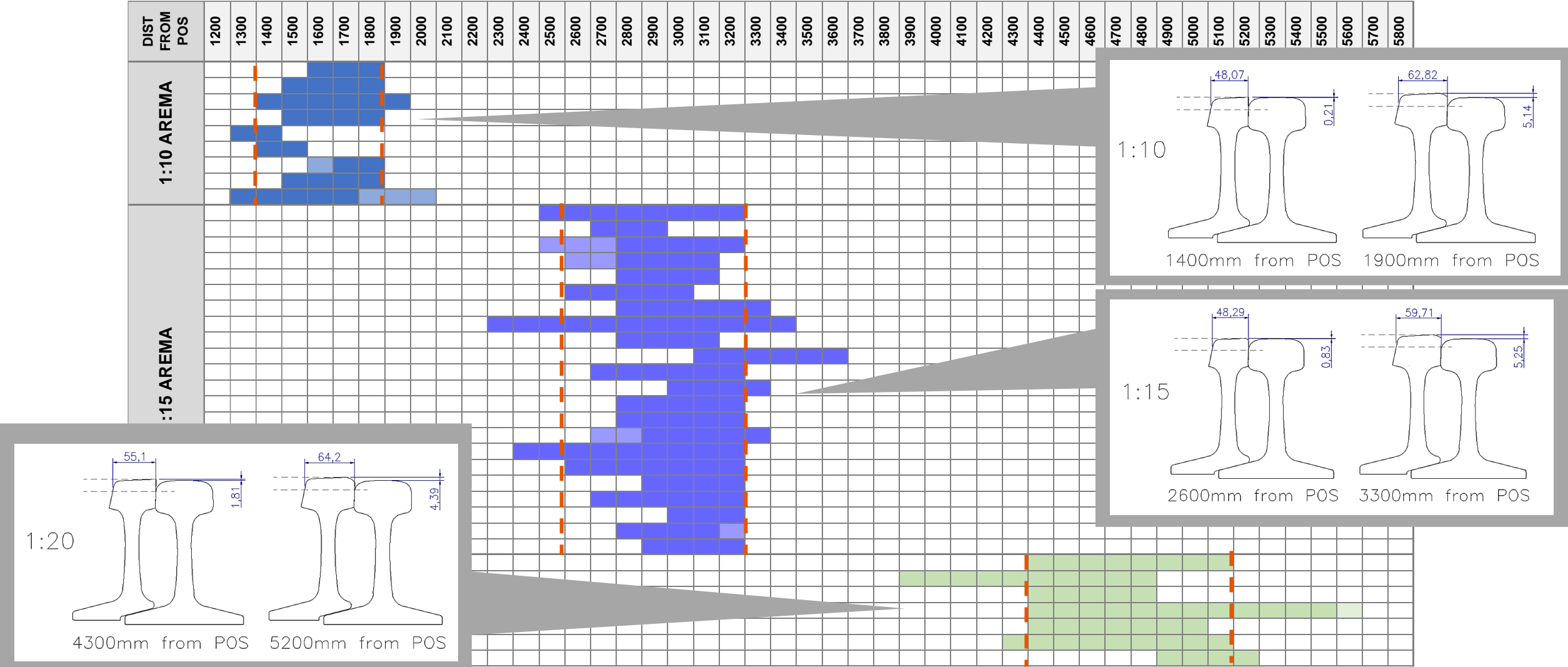
Turnouts performance

FSC development – Length



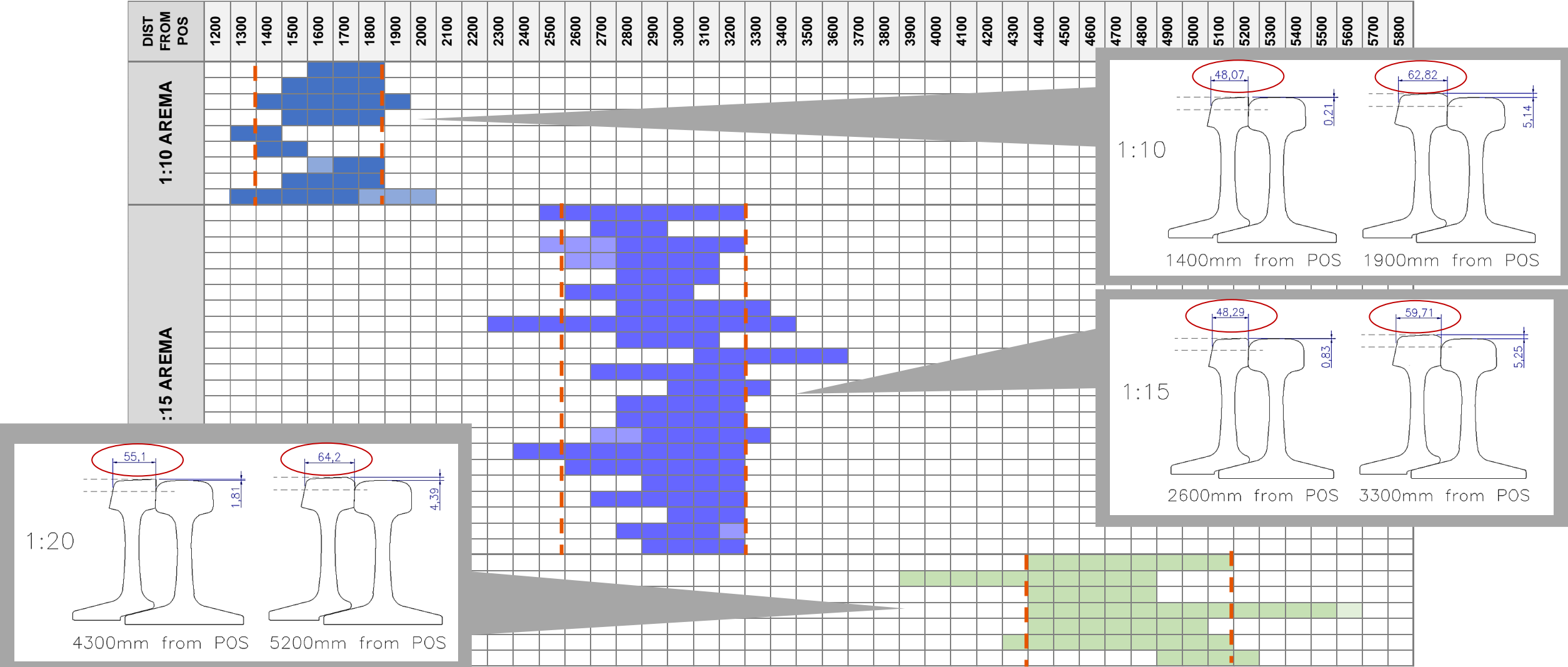
Turnouts performance

FSC development – Length



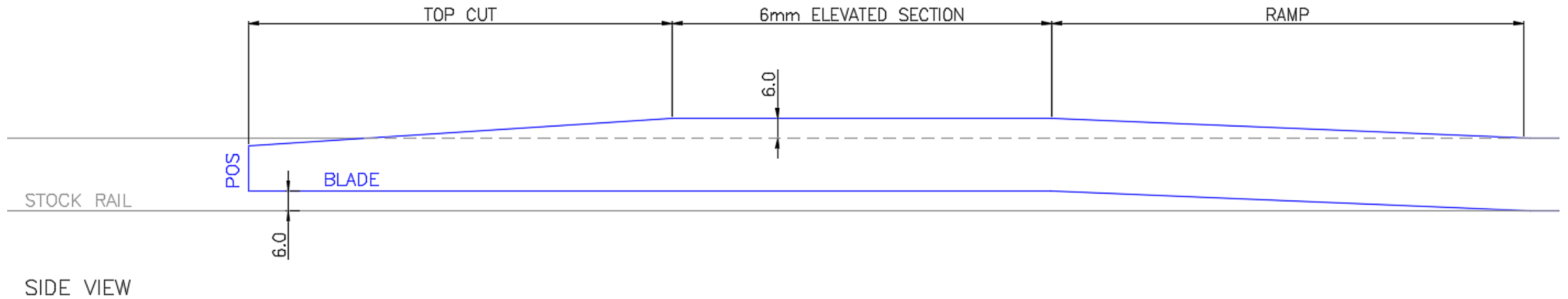
Turnouts performance

FSC development – Length



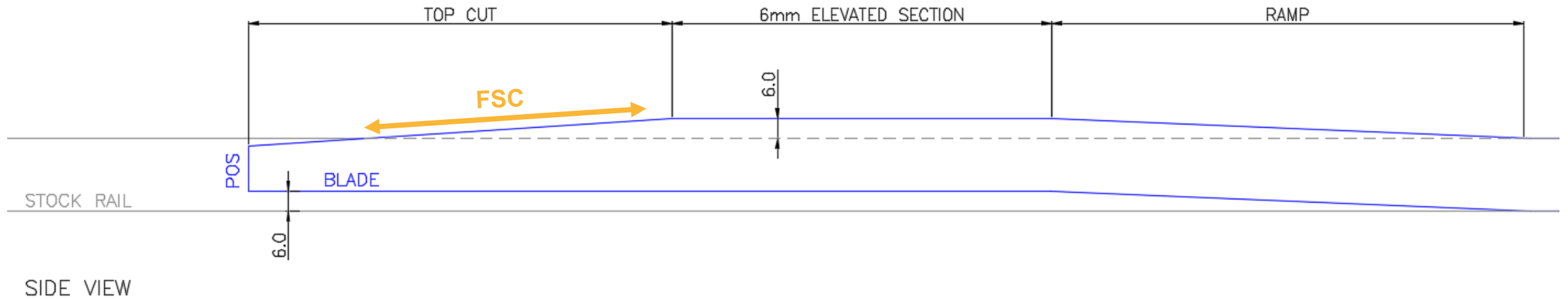
Turnouts performance

FSC development – Length



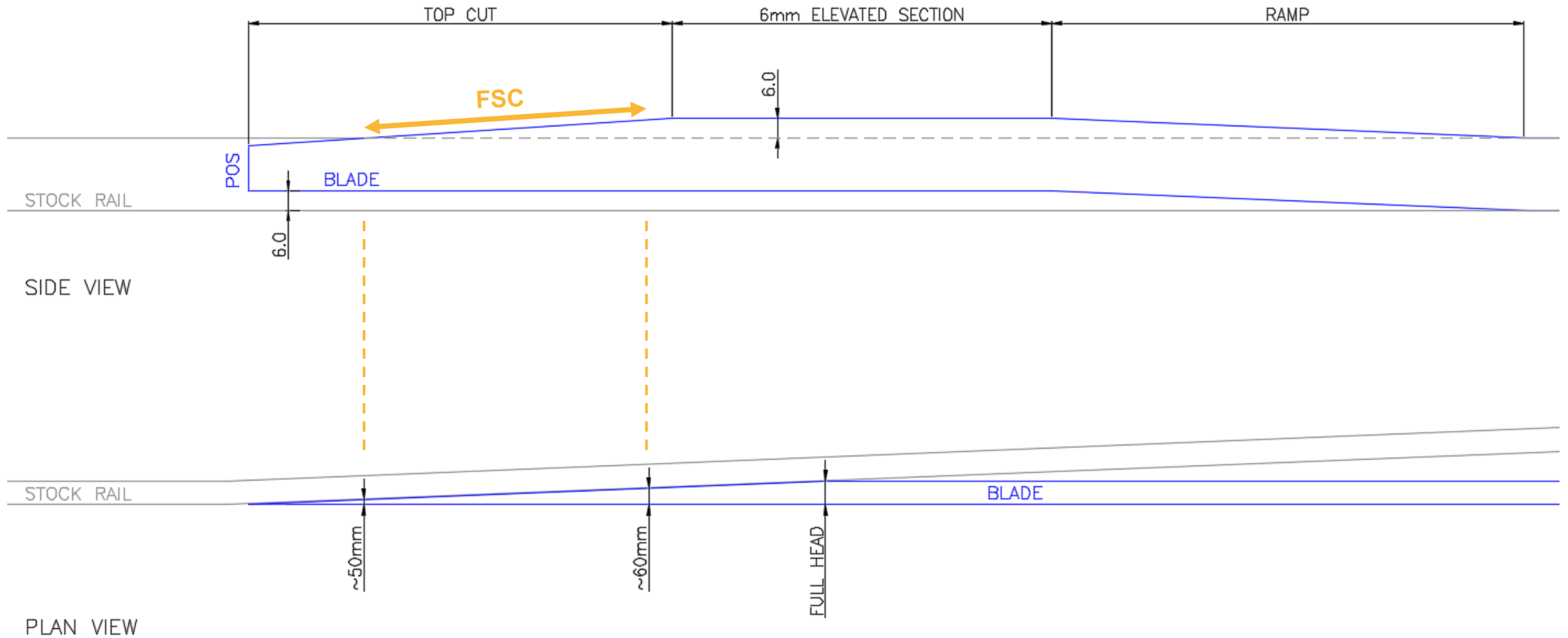
Turnouts performance

FSC development – Length



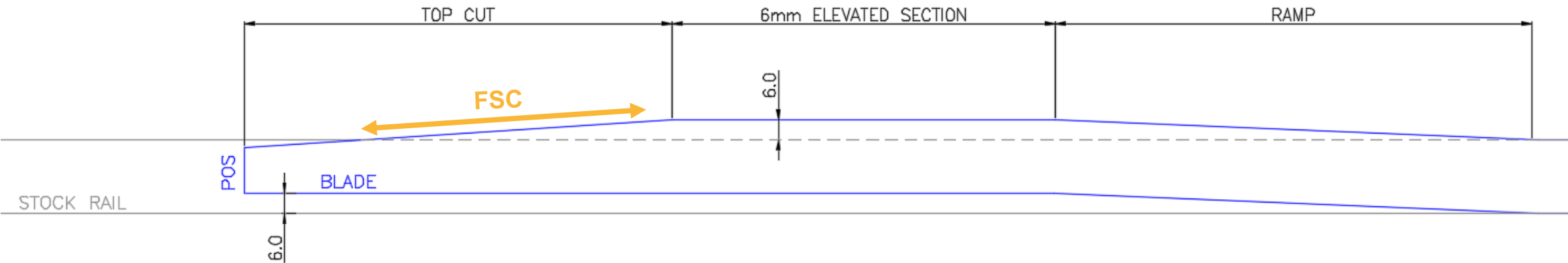
Turnouts performance

FSC development – Length



Turnouts performance

FSC development – Length



SIDE VIEW

Turnout rate	SR&B same level	FSC zone		Top cut end	6mm elevated section end	Ramp end
	from POS (mm)	from	to	from POS (mm)	from POS (mm)	from POS (mm)
1:10	1551	1400	1800	2133	3276	4343
1:15	2660	2600	3300	3658	6376	8459
1:20	4790	4300	5100	6096	9250	11350

Turnouts performance

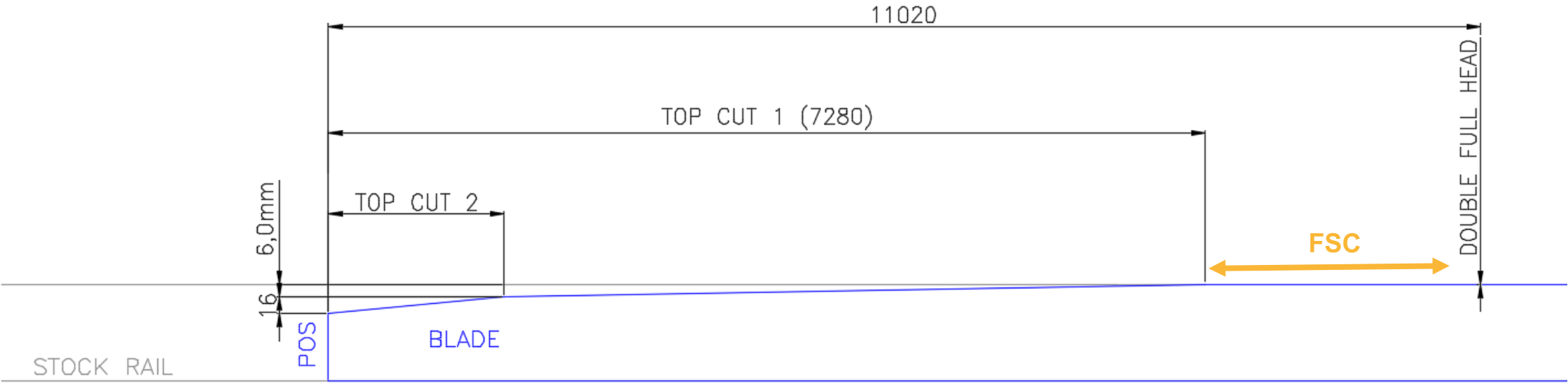
FSC development – Length

DIST FROM POS	7000	7100	7200	7300	7400	7500	7600	7700	7800	7900	8000	8100	8200	8300	8400	8500	8600	8700	8800	8900	9000	9100	9200	9300	9400	9500	9600	9700	9800	9900	10000	10100	10200	10300	10400	10500	10600	10700	10800	10900	11000	
1:20 TANG																																										

Turnouts performance

FSC development – Length

DIST FROM POS	7000	7100	7200	7300	7400	7500	7600	7700	7800	7900	8000	8100	8200	8300	8400	8500	8600	8700	8800	8900	9000	9100	9200	9300	9400	9500	9600	9700	9800	9900	10000	10100	10200	10300	10400	10500	10600	10700	10800	10900	11000	
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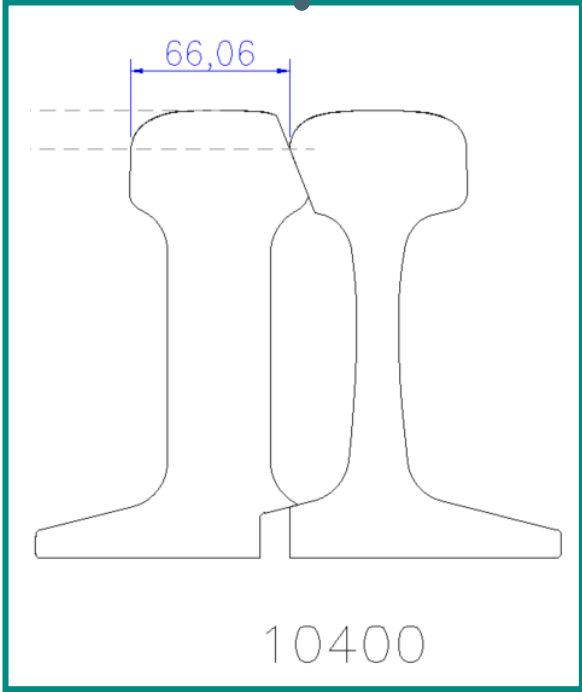
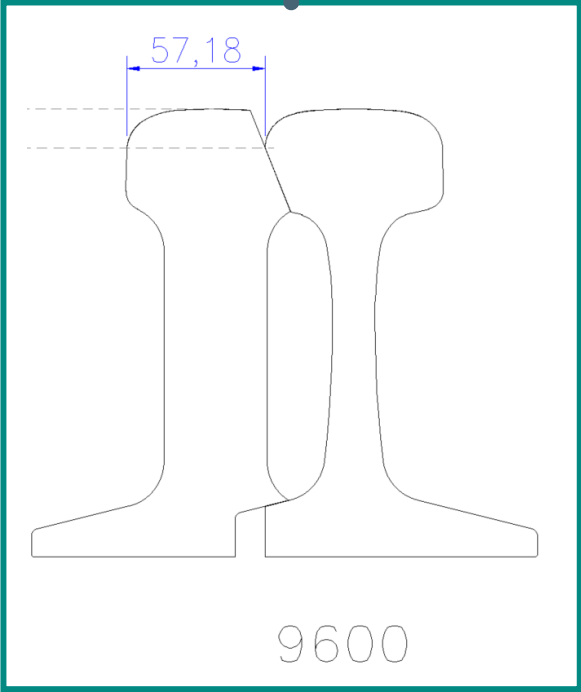
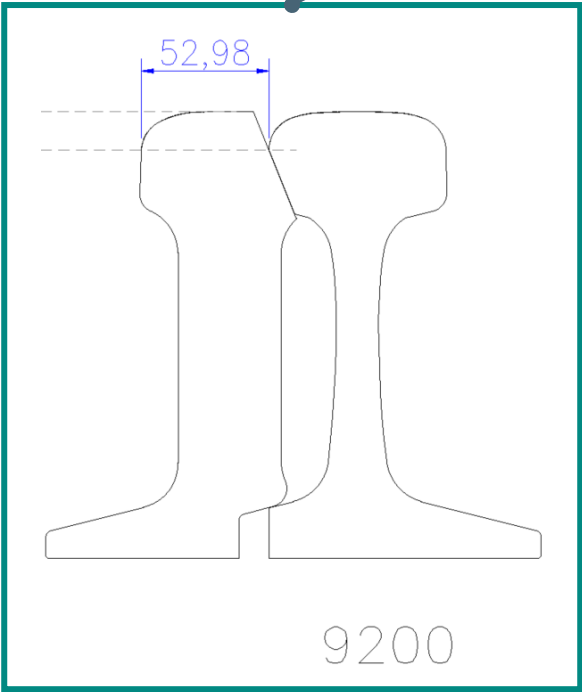


SIDE VIEW

Turnouts performance

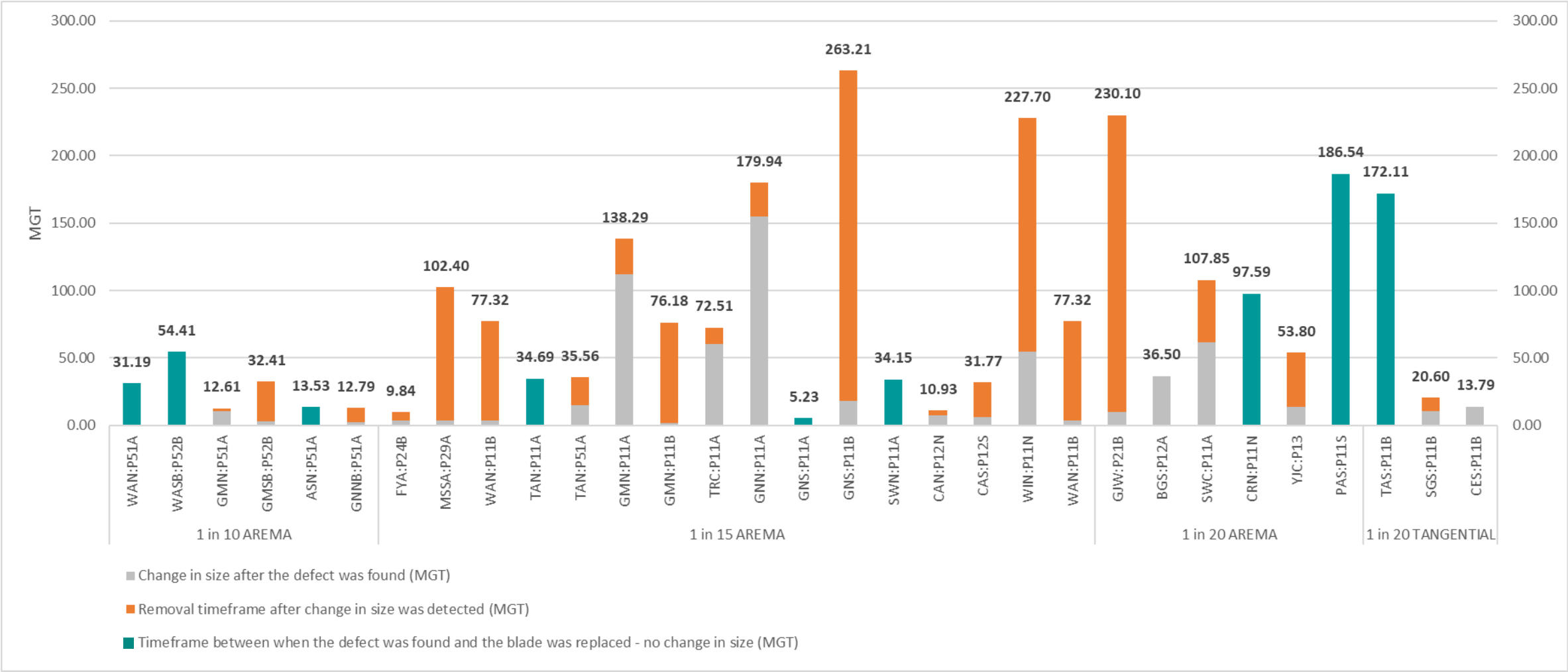
FSC development – Length

DIST FROM POS	7000	7100	7200	7300	7400	7500	7600	7700	7800	7900	8000	8100	8200	8300	8400	8500	8600	8700	8800	8900	9000	9100	9200	9300	9400	9500	9600	9700	9800	9900	10000	10100	10200	10300	10400	10500	10600	10700	10800	10900	11000				
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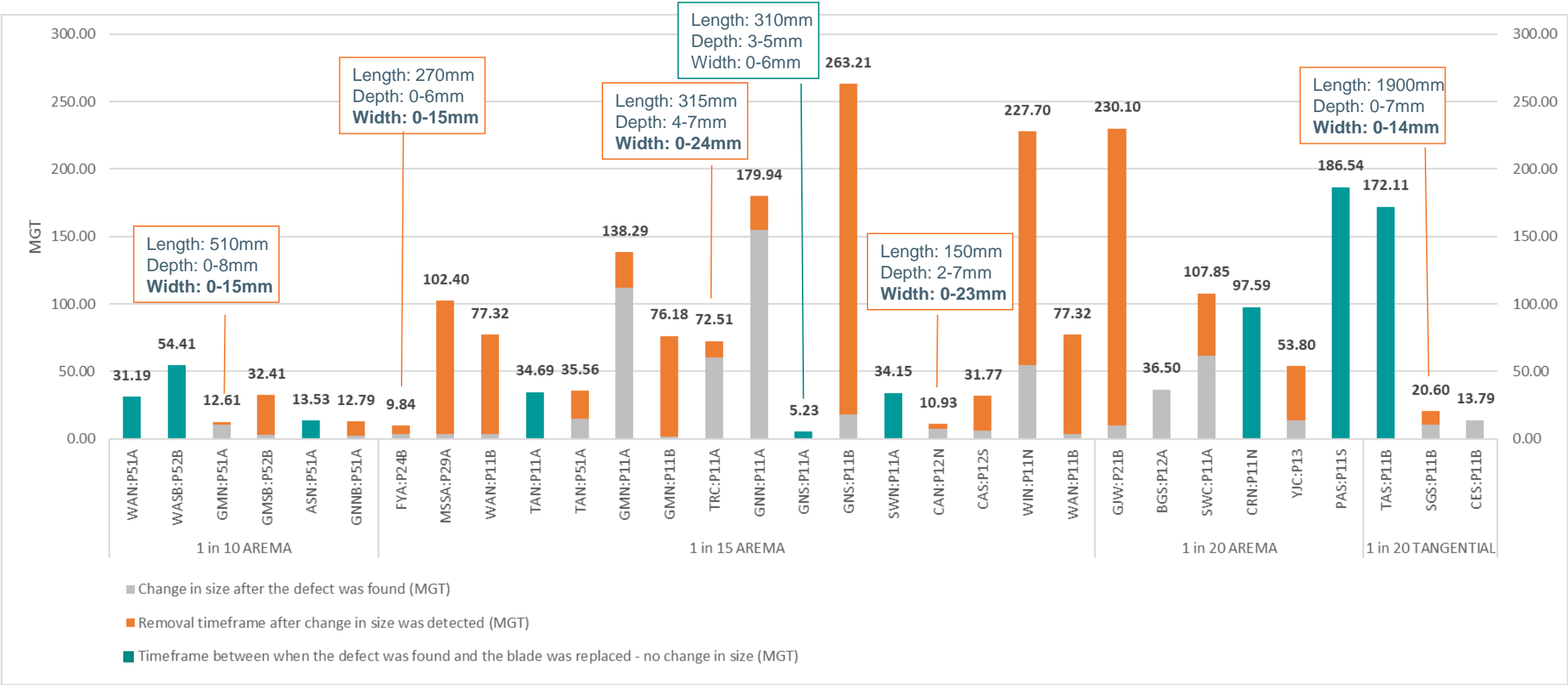
Turnouts performance

FSC development



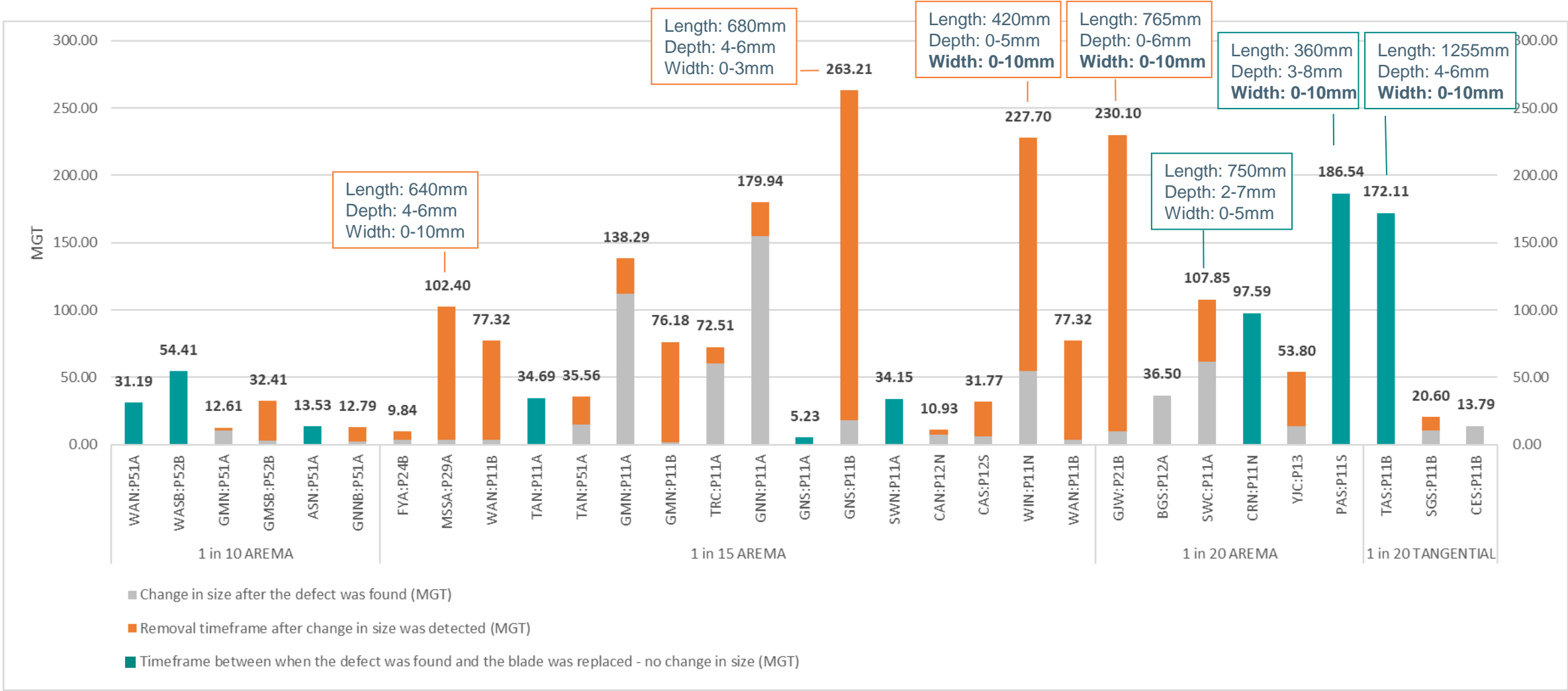
Turnouts performance

FSC development



Turnouts performance

FSC development



4. Initiatives

Initiatives

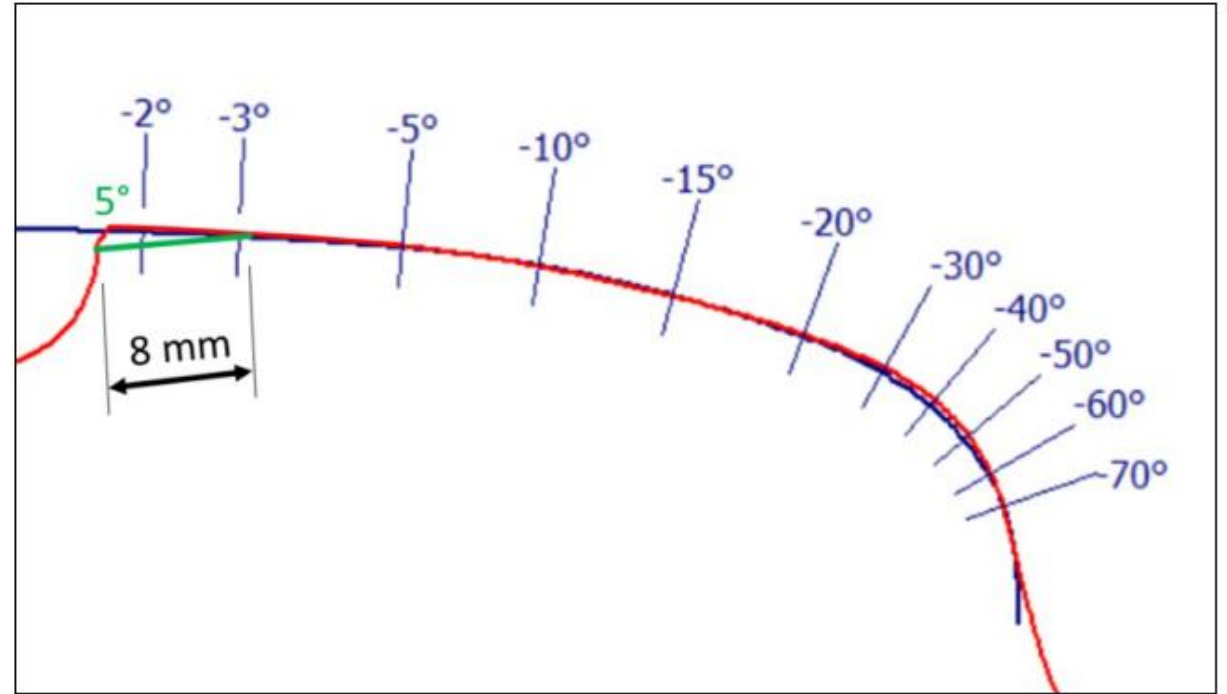
Work Instruction

Work instruction 0173018 – Grinding to Prevent Field Side Cracking in Switch Blades

Grind a single 5° facet up to 8mm wide along the field edge.

Higher angles remove material support and can result in more rapid flow development.

Care must be taken not to impact the stock rail during grinding.

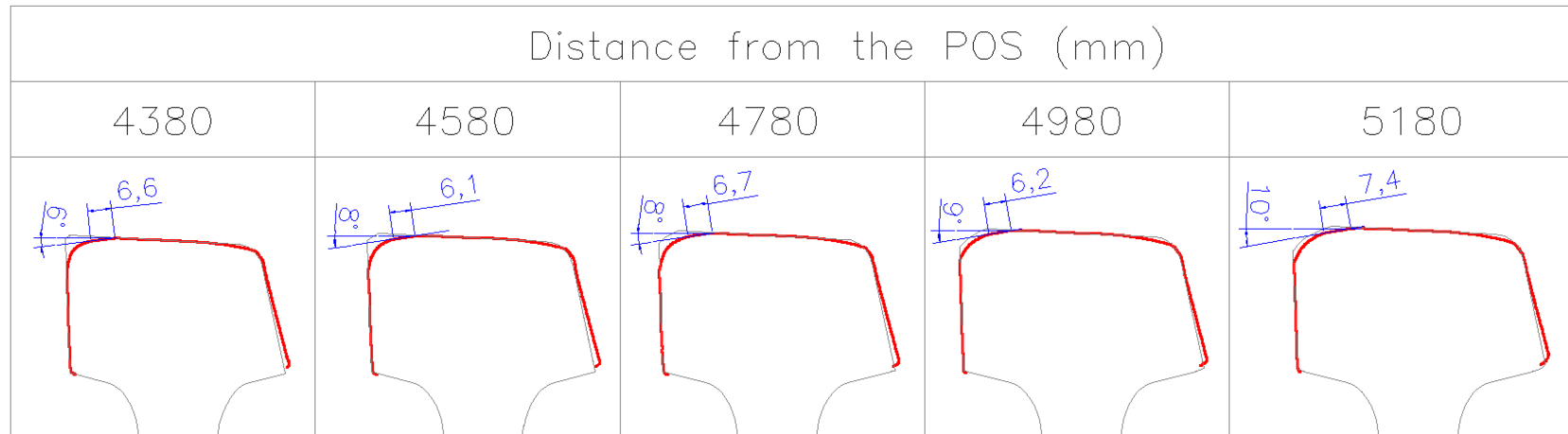


Source: Work Instruction 0173018 - Grinding to Prevent Field Side Cracking in Switch Blades

Initiatives

Hand grind – 1:20 AREMA turnout

Profile measurements were taken after grinding to check compliance to the Work Instruction



Profile measurements from a 1:20 AREMA turnout – after hand grinding

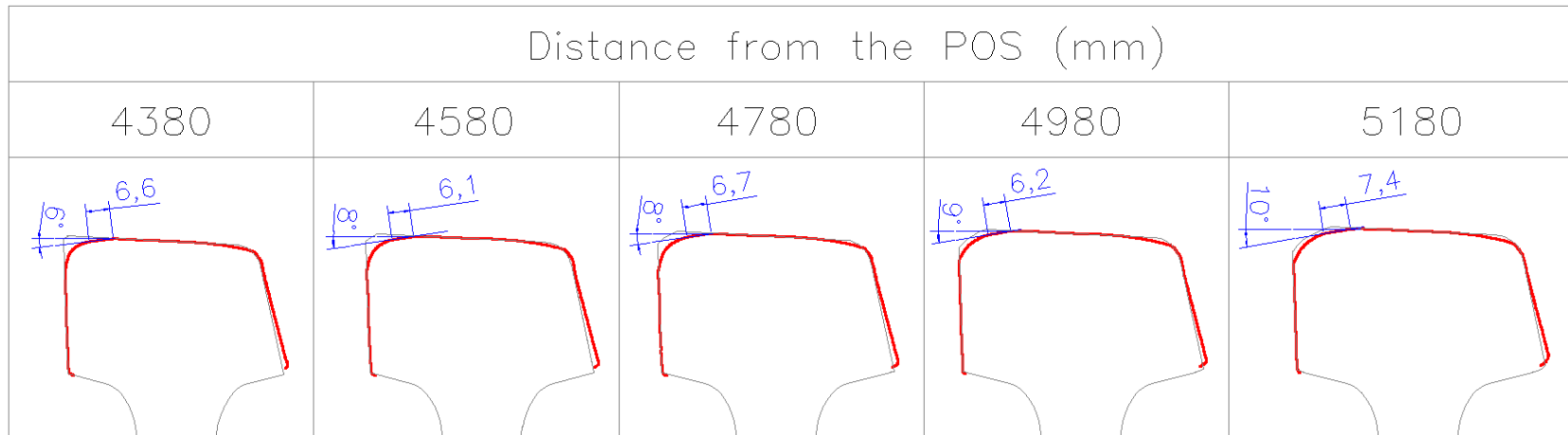


1:20 AREMA turnout

Initiatives

Hand grind – 1:20 AREMA turnout

Profile measurements were taken after grinding to check compliance to the Work Instruction



Profile measurements from a 1:20 AREMA turnout – after hand grinding

Next steps:

- Protractor to be used
- Customised gauge to be designed
- Management of stock rail and blade differential height



1:20 AREMA turnout

Initiatives

Trial at Chichester Backtrack – 1:15 AREMA RH Turnout

Profile measurements were taken before and after grinding on both blades to check compliance to the Work Instruction



Profile measurements were taken before and after grinding

Initiatives

Trial at Chichester Backtrack – 1:15 AREMA RH Turnout

Example: profile measurement taken at 3000mm from POS – before grinding



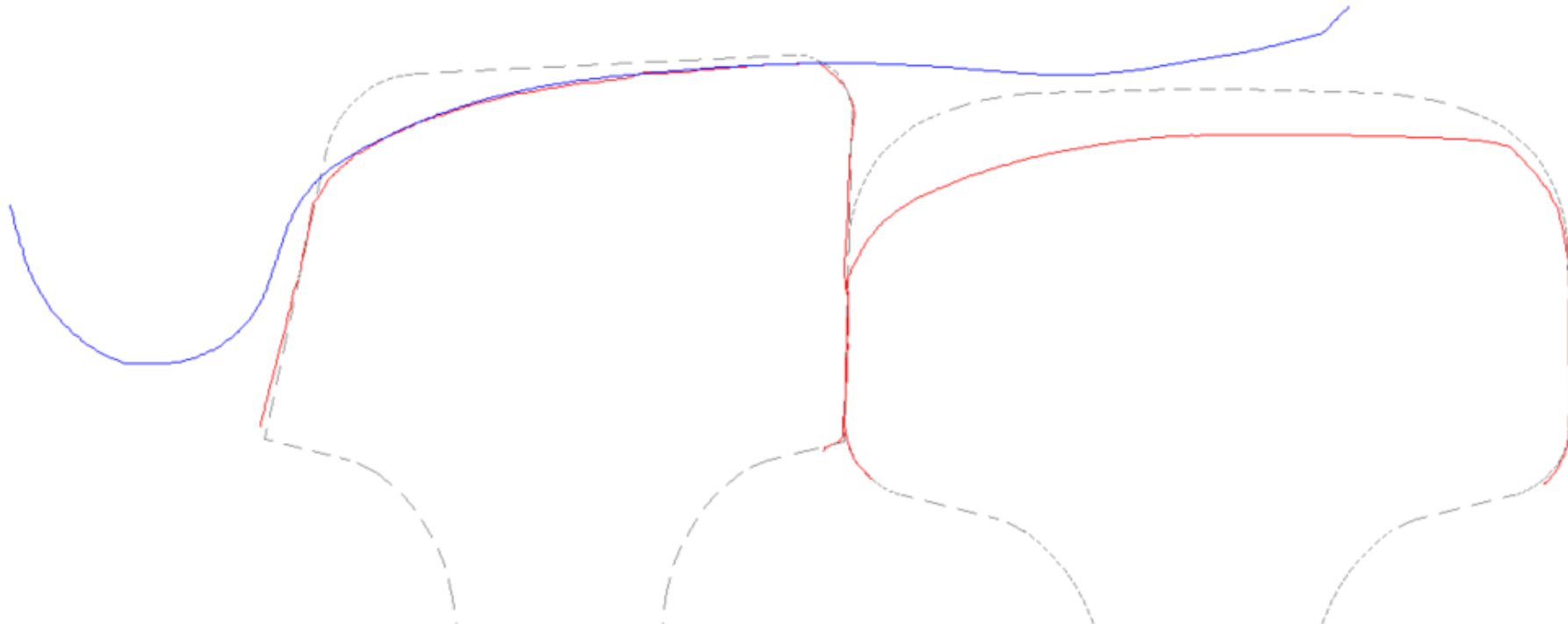
RH Blade, No. 5 = 3000mm from POS

Initiatives

Trial at Chichester Backtrack – 1:15 AREMA RH Turnout

Example: profile measurement taken at 3000mm from POS – before grinding

1.2 Hollow

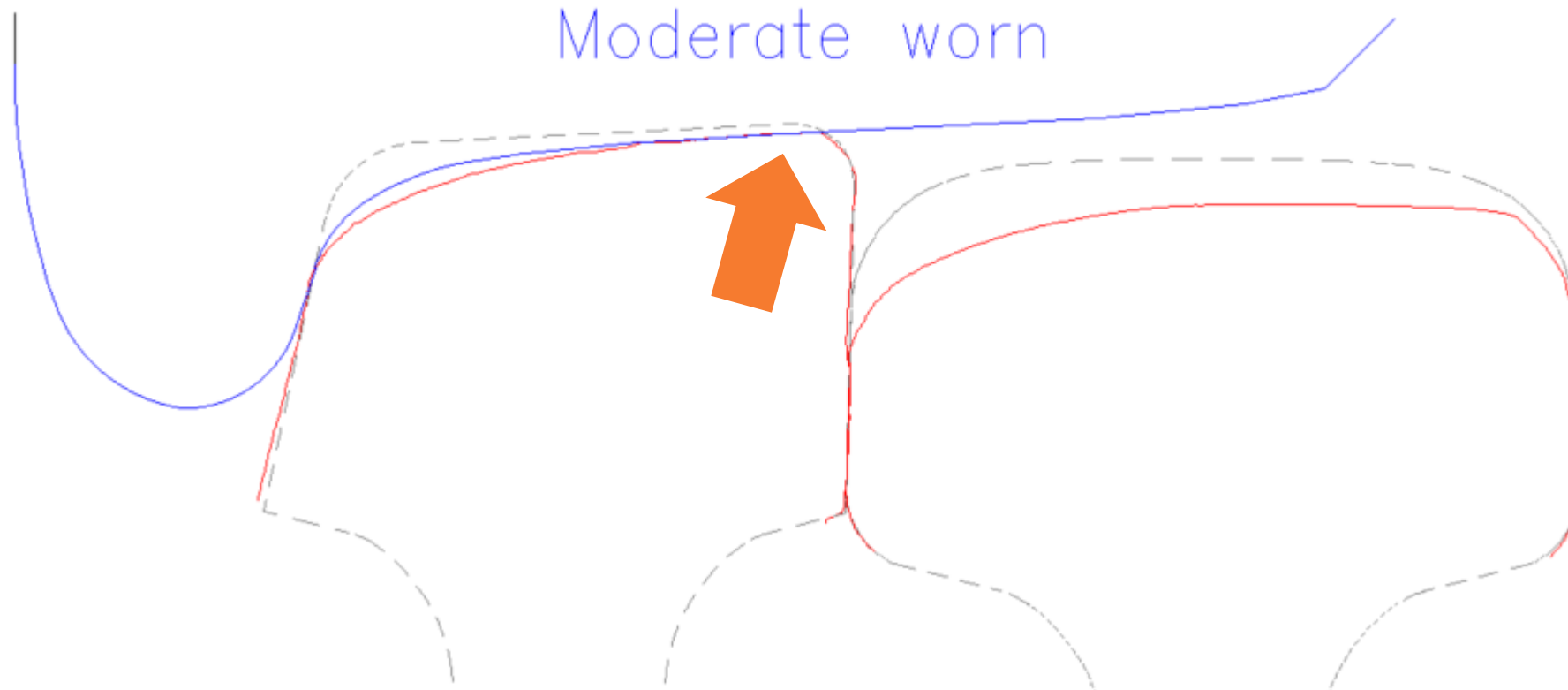


RH Blade, 3000mm from POS – Before grinding – Hollow wheel

Initiatives

Trial at Chichester Backtrack – 1:15 AREMA RH Turnout

Example: profile measurement taken at 3000mm from POS – before grinding

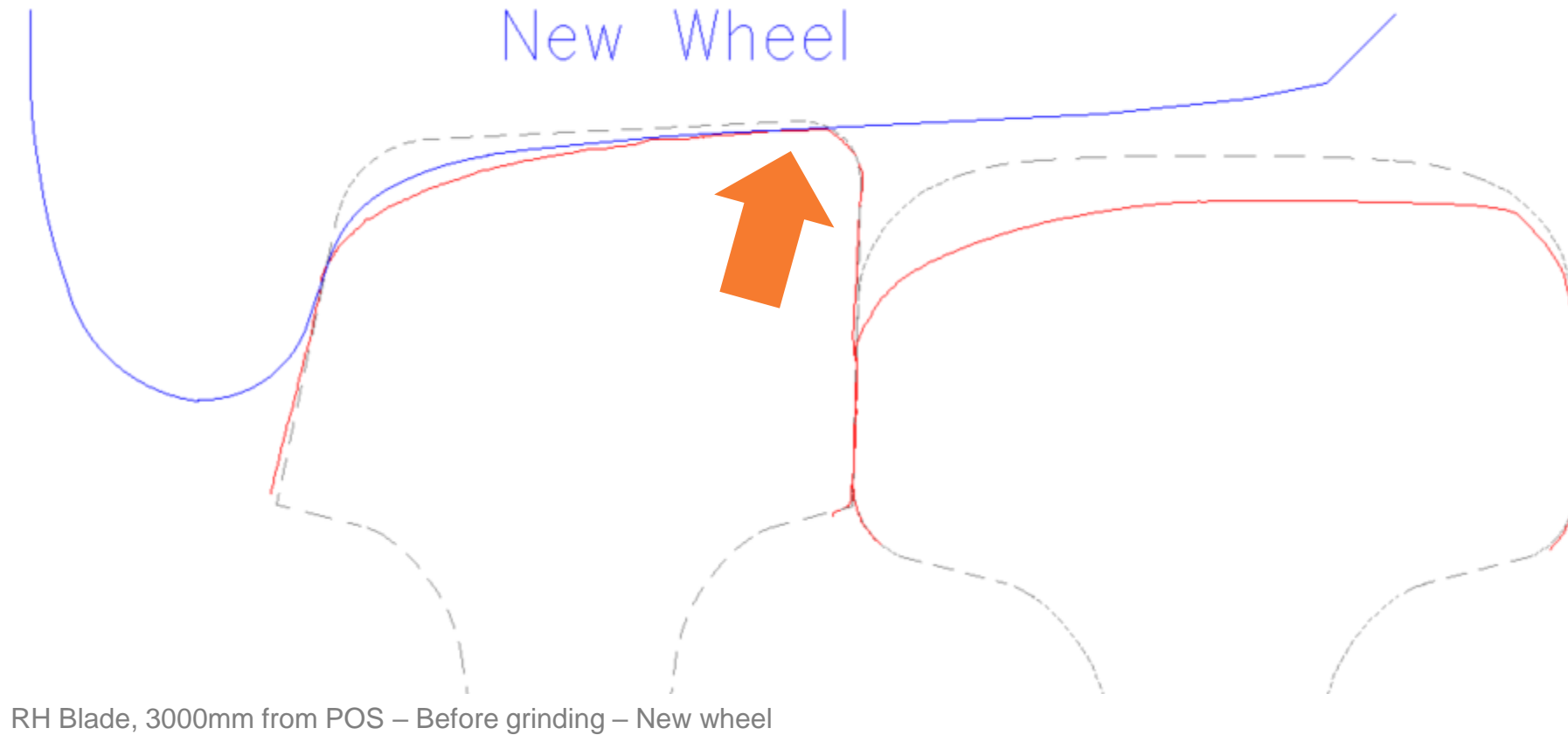


RH Blade, 3000mm from POS – Before grinding – Moderate worn

Initiatives

Trial at Chichester Backtrack – 1:15 AREMA RH Turnout

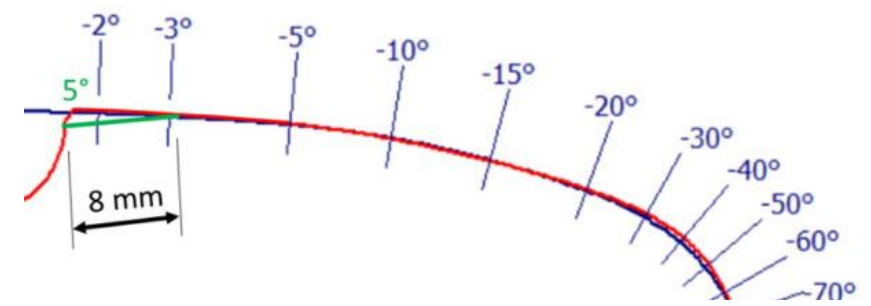
Example: profile measurement taken at 3000mm from POS – before grinding

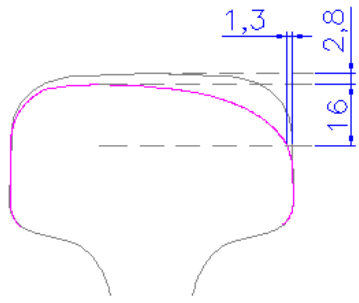
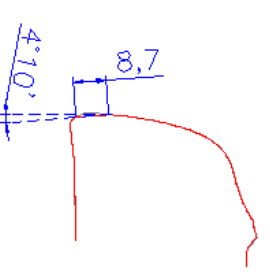
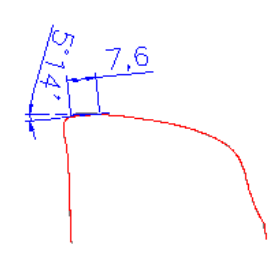
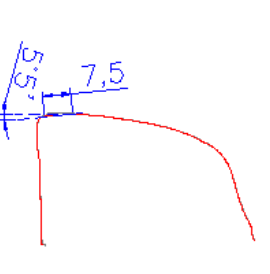
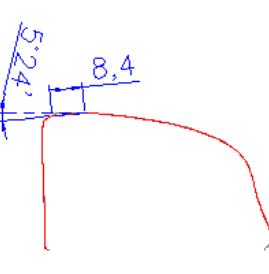

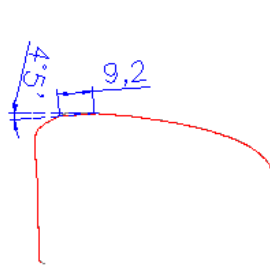
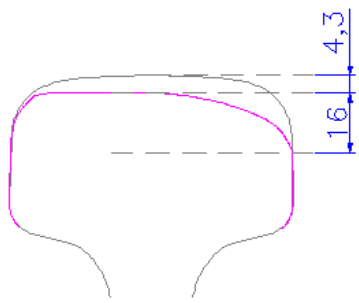
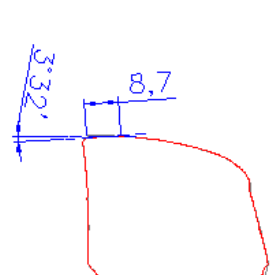
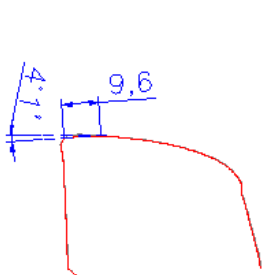
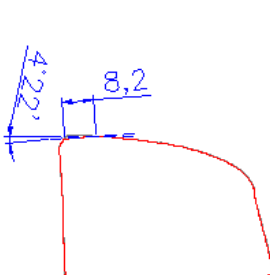
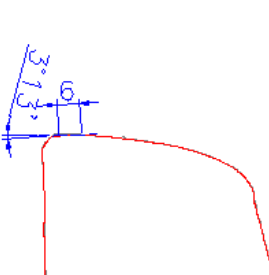
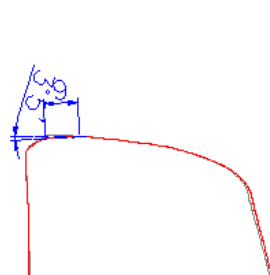
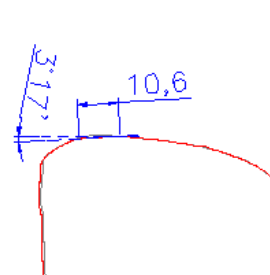


Initiatives

Trial at Chichester Backtrack – 1:15 AREMA RH Turnout

Profile measurements taken after grinding



		Distance from the POS (mm)						
		-200	2250	2500	2750	3000	3250	3500
RH								
LH								

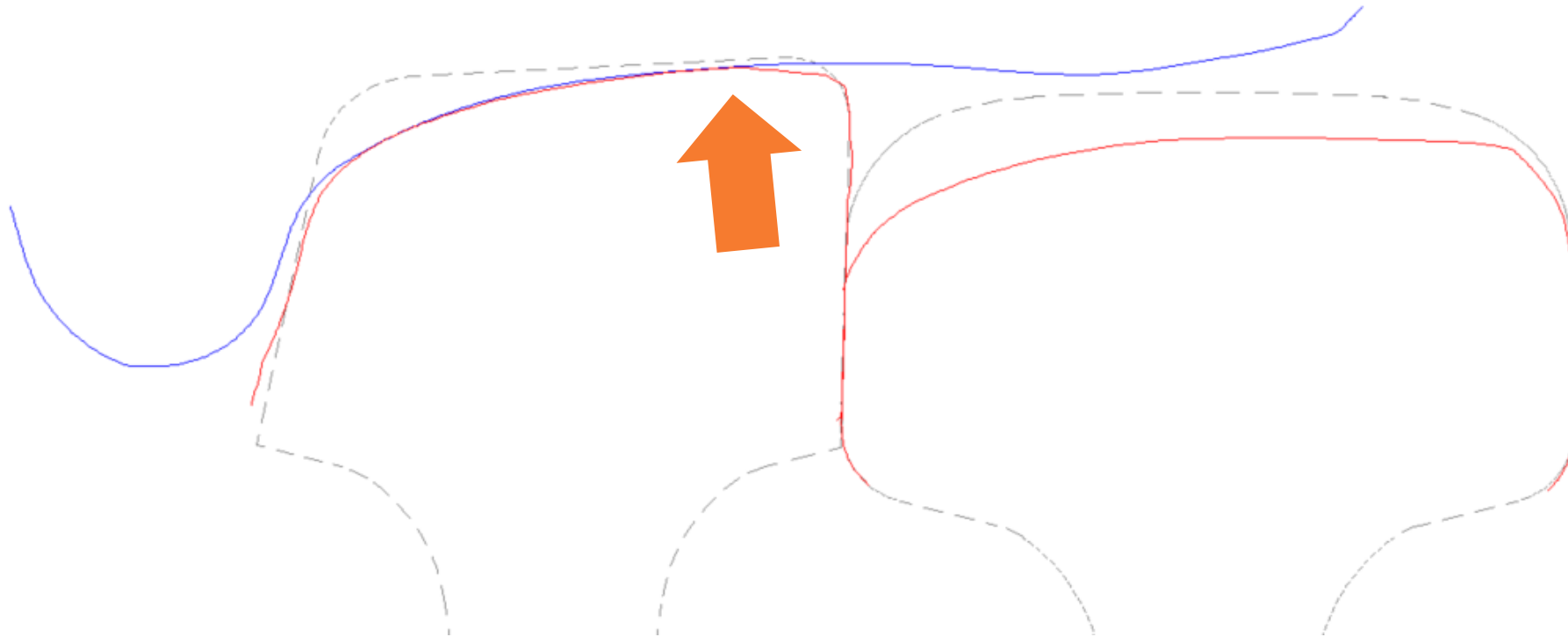
Profile measurements after grinding

Initiatives

Trial at Chichester Backtrack – 1:15 AREMA RH Turnout

Example: profile measurement taken at 3000mm from POS – after grinding

1.2 Hollow

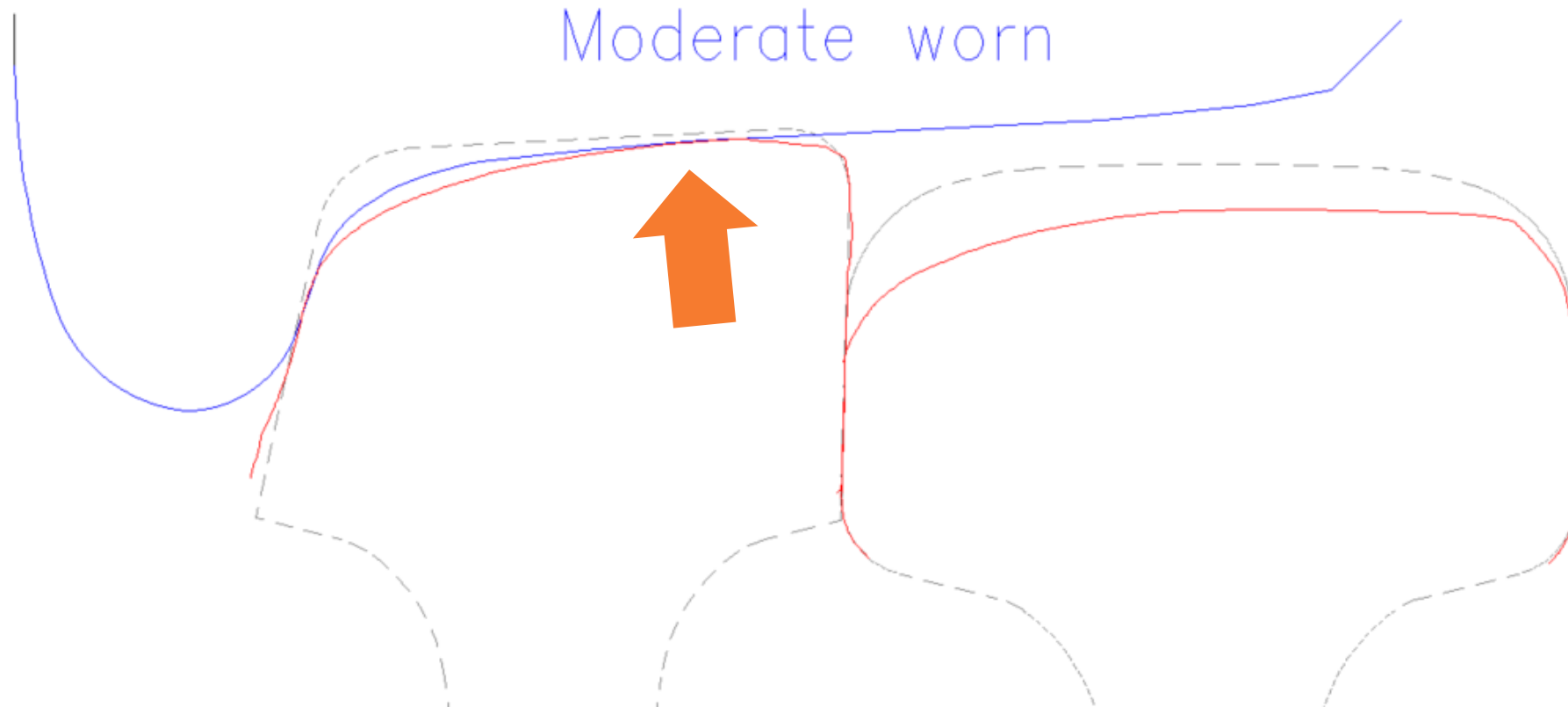


RH Blade, 3000mm from POS – After grinding – Hollow wheel

Initiatives

Trial at Chichester Backtrack – 1:15 AREMA RH Turnout

Example: profile measurement taken at 3000mm from POS – after grinding

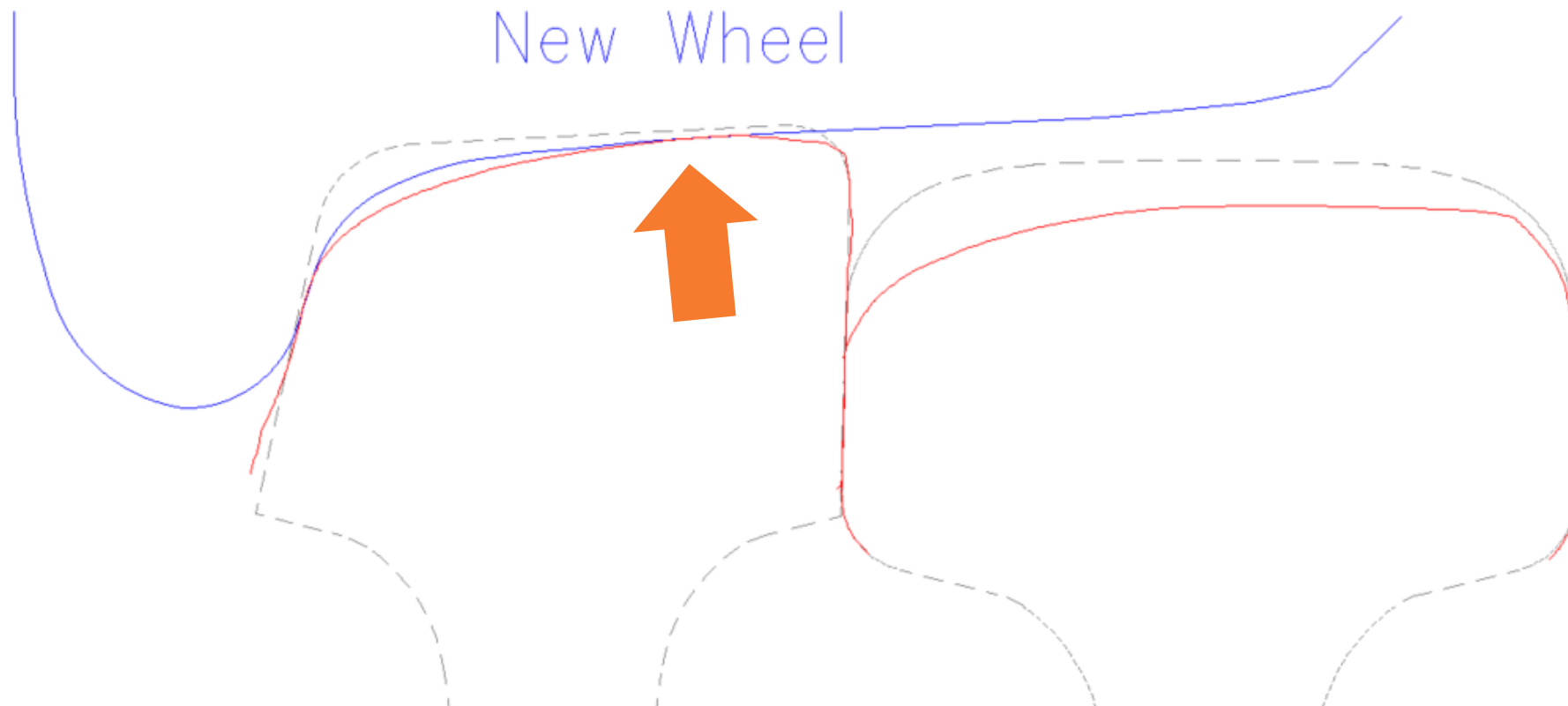


RH Blade, 3000mm from POS – After grinding – Moderate worn wheel

Initiatives

Trial at Chichester Backtrack – 1:15 AREMA RH Turnout

Example: profile measurement taken at 3000mm from POS – after grinding



RH Blade, 3000mm from POS – After grinding – New wheel

Initiatives

Trial at Chichester Backtrack – 1:15 AREMA RH Turnout



Right hand blade



Left hand blade

Initiatives

Trial at Chichester Backtrack – 1:15 AREMA RH Turnout



Right hand blade



Left hand blade

Next steps:

- Monitor and if successful, include it in the Maintenance Strategy
- Optimise the turnout design implementing the 5 degrees facet from the manufacturing stage

Initiatives

Pre-Profiling Project



Main goals:

- 1) Increase safety
- 2) Increase the performance of the turnout components and wheels
- 3) Reduce track time to implement the desired profiles
- 4) Develop maintenance strategy and support to control defects and prevent failures

Proposed profiles (trial) – initial verification

Initiatives

Pre-Profiling Project



Proposed profiles (trial) – initial verification

Main goals:

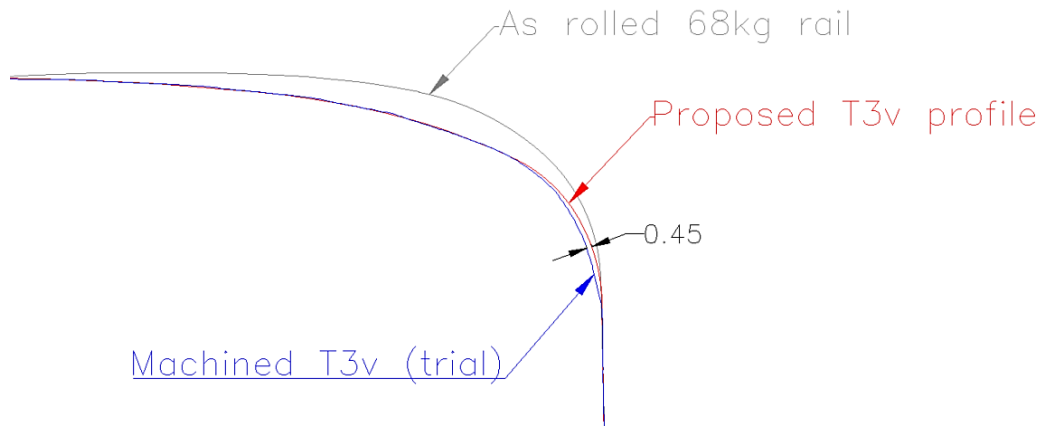
- 1) Increase safety
- 2) Increase the performance of the turnout components and wheels
- 3) Reduce track time to implement the desired profiles
- 4) Develop maintenance strategy and support to control defects and prevent failures

Initial analysis:

- 1) Existing turnouts and wheels' performance analysis
- 2) Simulate wheel-rail impact loading under new and worn turnouts and wheel profiles
- 3) Simulate wheel-rail contact dynamically under different conditions (new/ moderate worn/ hollow wheels, new/ worn rails, facing/ trailing directions, straight/ reverse routes)
 - a) Propensity for wear, plastic deformation and RCF development
 - b) Flange climb risk

Initiatives

Pre-Profiling Project



Comparison between proposed and machined profiles

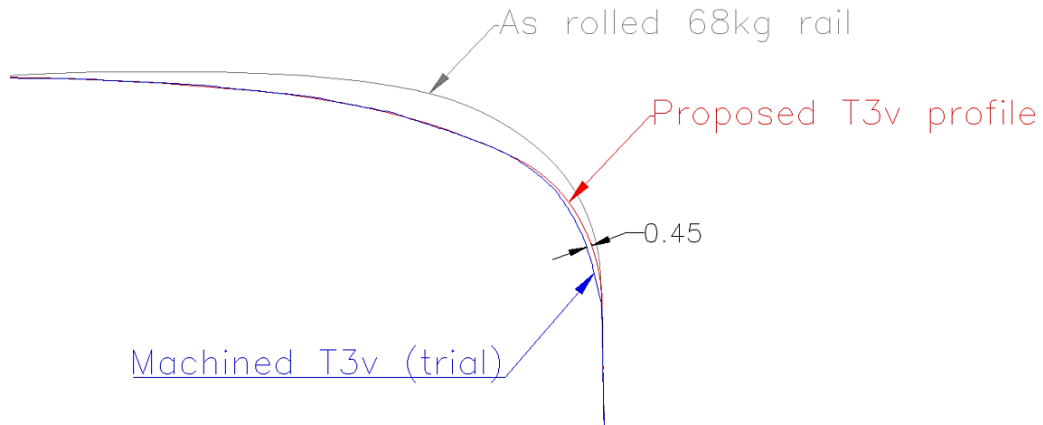


New turnout profiles:

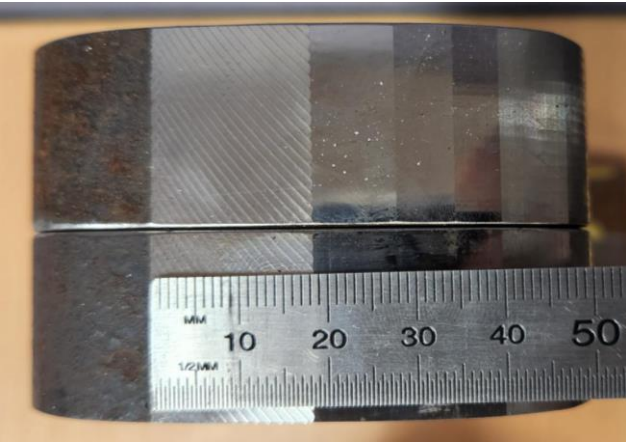
- 1) Customise and optimise the wheel-rail contact
- 2) Re-simulate
- 3) Modelling

Initiatives

Pre-Profiling Project



Comparison between proposed and machined profiles



New turnout profiles:

- 1) Customise and optimise the wheel-rail contact
- 2) Re-simulate
- 3) Modelling

Next Steps:

- 1) Finalise the stock rail and blade analysis
- 2) Re-assess the whole turnout set after modelled
- 3) Manufacture
- 4) Trial
- 5) Monitor and validate
- 6) Amend and re-simulate, if necessary
- 7) Implementation
- 8) Training, tools, development of maintenance thresholds and strategy to control defects and failure prevention

5. Conclusion

In conclusion

Turnouts increase the railway system's capacity, providing strategic and operational flexibility. On the other hand, the desired operational excellence in heavy haul railways requires constant and proportional investment to match the efficiency challenges (such as the increase in train size, speed, axle load and headway reduction) with the permanent way capacity.

The trials and initiatives to enhance the turnouts' performance are only possible due to the continuous improvement processes, which requires synergy, engagement and partnership among all parties (Maintenance, Track Inspectors, Grinding, Reliability, Engineering, the Manufacturer and the Institute of Railway Technology).

Acknowledgement

I would like to thank all my railways colleagues that took or are taking part in this learning journey of discovery with me.



References

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Thank you!

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