

RAILWAY SYSTEMS
by voestalpine

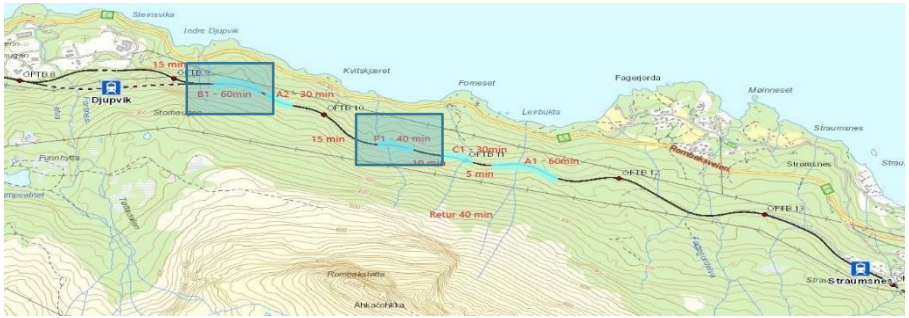
400UHC® XR HSH®
Ofotline In-Service Testing

Curves B1 and P1
Project Status after Autumn 2022 Grinding and LCC Assessment

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400UHC® XR HSH®
Frame Conditions – Test Site





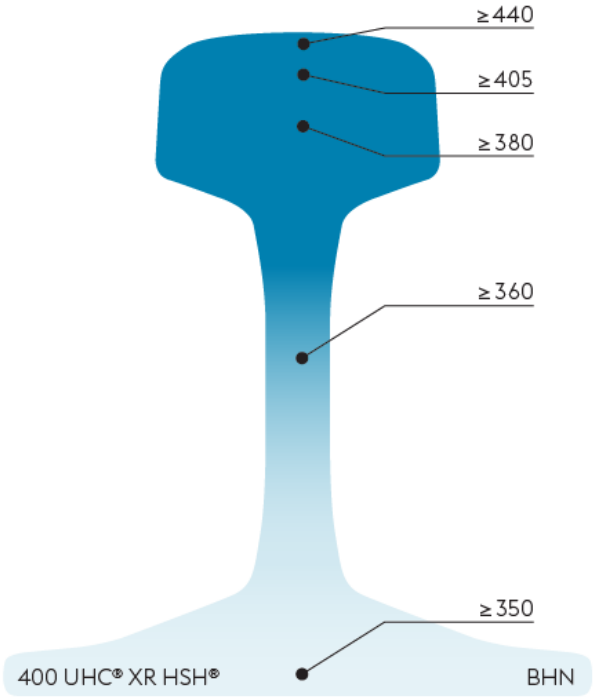
- Iron ore line Kiruna – Narvik (loaded in one direction)
- Yearly traffic (track): 32-35MGT
- maximum axle load: 25-30 to (single wagons up to 32 to)
- Curve radius 350m
- Loaded to West 60 kph
- Unloaded to East 80 kph

- test objective
  - RCF, Wear
- tested rails (54E4):
  - 400UHC® HSH®
  - 400UHC ® XR HSH®

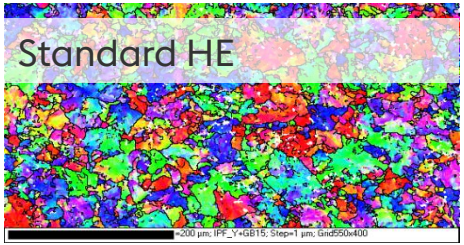
400UHC® XR HSH®

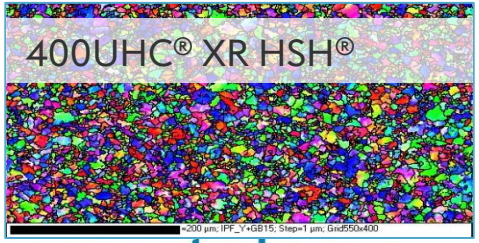
Product Information - Concept

RAILWAY SYSTEMS



- **Evolutionary steel design:**
  - Deep head hardened pearlitic rail steel with grain refinement (toughness) and strengthened lamellar structure (wear and RCF performance).
- **Maximum safety:**
  - Soft web and soft foot ensure highest safety in track
  - Very fine and perfectly lamellar structure

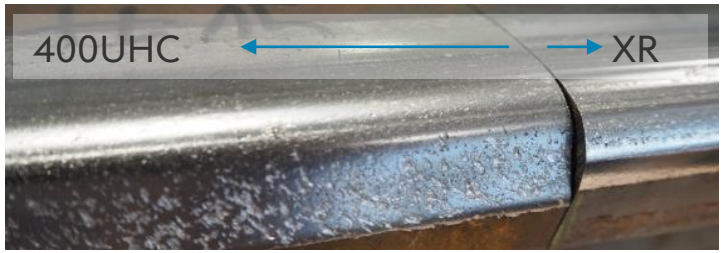


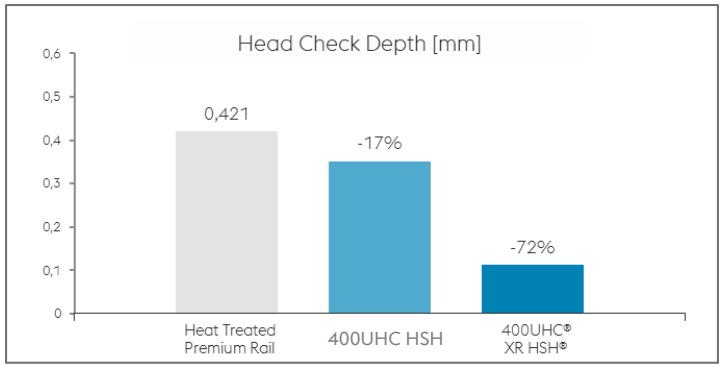


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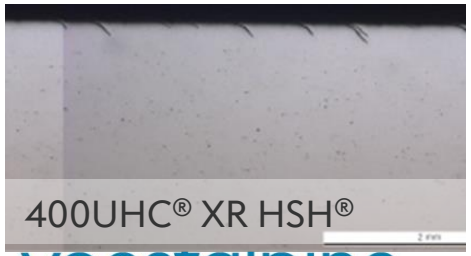
Product Information – Test Rig Results





- Evolutionary steel design:
  - Deep head hardened pearlitic rail steel with grain refinement (toughness) and strengthened lamellar structure (wear and RCF performance).
- Maximum safety:
  - Soft web and soft foot ensure highest safety in track
  - Very fine and perfectly lamellar structure
- Best performance:
  - Highest resistance to wear of all pearlitic rail steels
  - Highest resistance to rolling contact fatigue





Joint Welding XR/XR 54 90HPW-E

Installation: 04.06.2019, 4°C

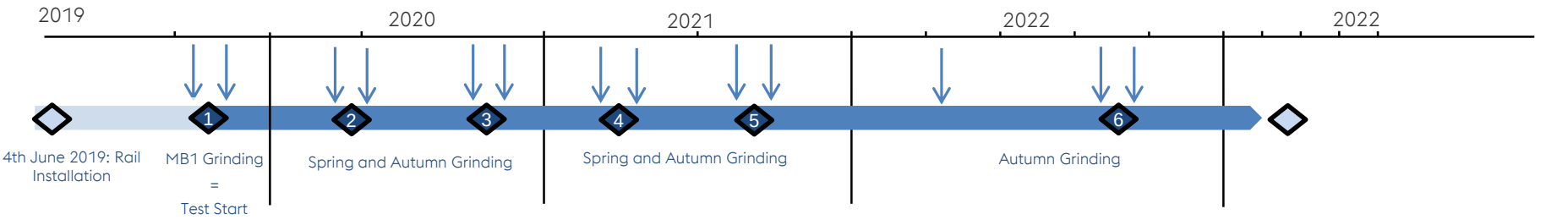
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400 UHC® XR HSH® Timeline

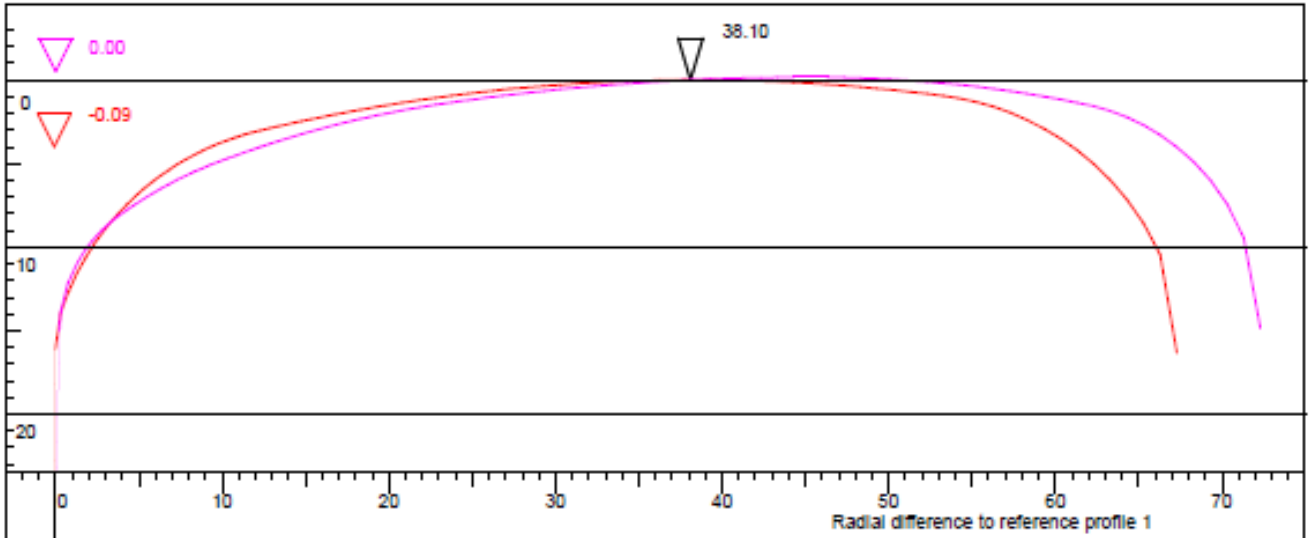


- » P1: Installation in June 2019 (2x120m, 54E4) only High Rail (LR:R370CrHT, 2013)
- » B1ref: Installation in June 2019 (400UHC Standard)
- » New layer grinding (54E4>>MB1v2) in autumn 2019 (start of the test)
- » Skipping of one complete grinding cycle in spring 2022
- » Miniprof-measurements and inspection before and after every grinding in spring and autumn

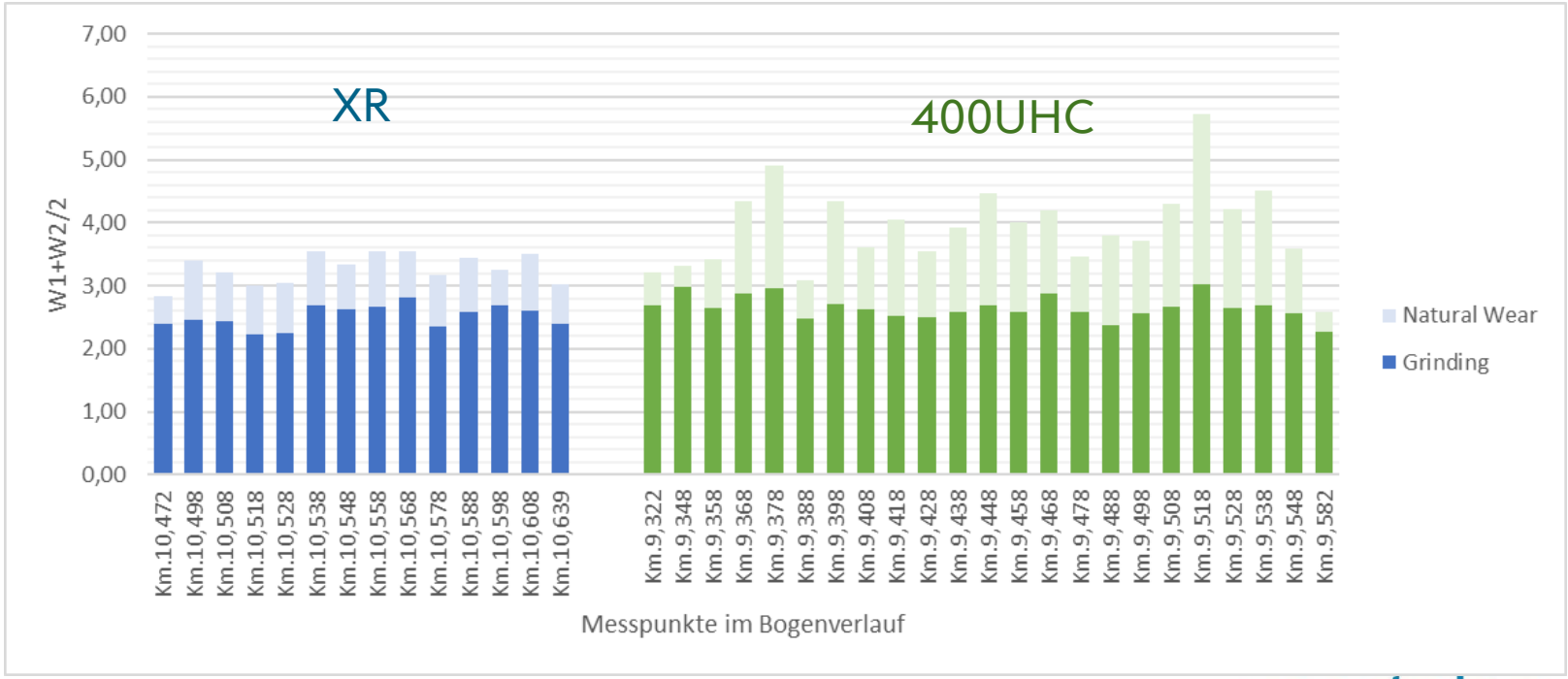


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Profile Comparison

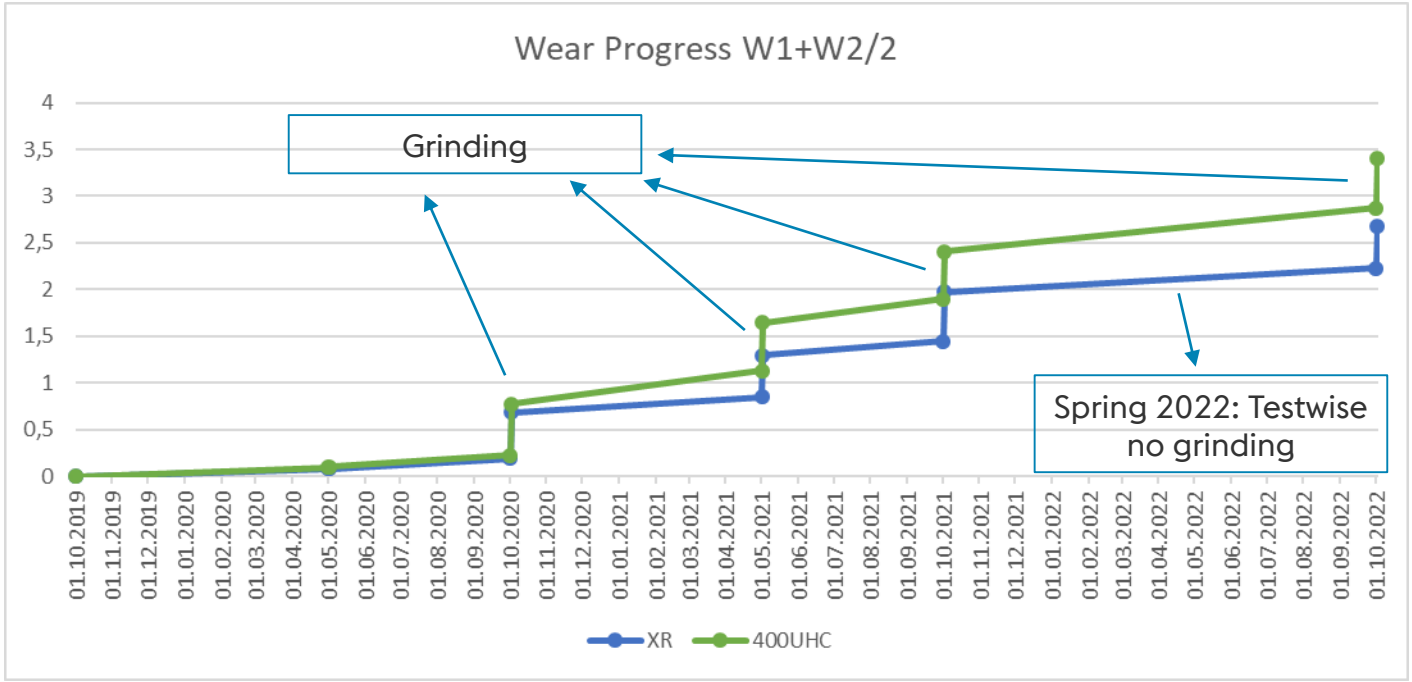


Natural and artificial Wear (Post Grind Autumn 2022)
Individual Measurement Points P1 und B1Ref

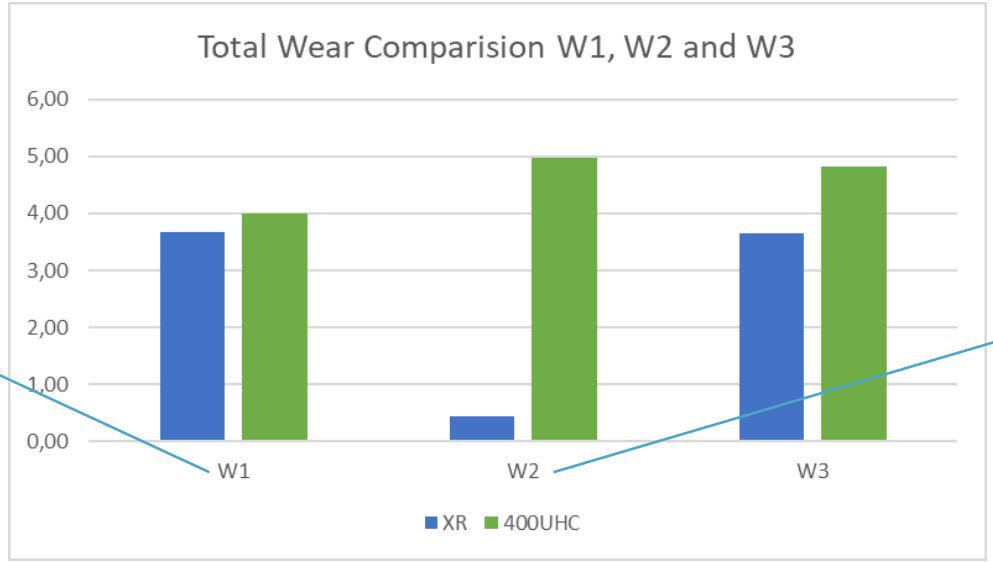


Total Wear

Average T Wear progress (total) P1 und B1Ref



Wear (Post Grind Autumn 2022)
Total Comparison W1, W2 and W3

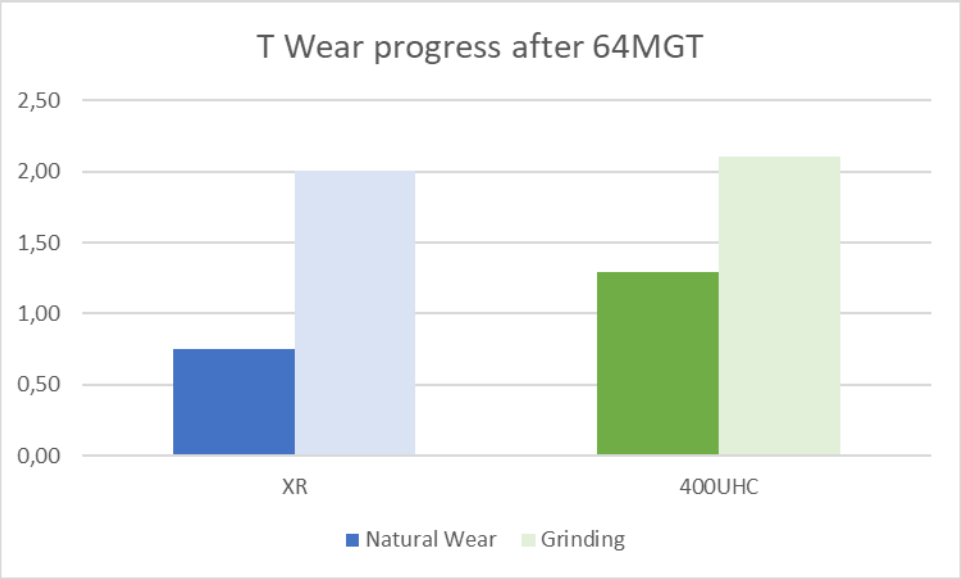


W1 (and W3) show mainly artificial wear because of grinding (both curves are ground in the same way during the testing period)

W2 show mainly natural side, since the artificial wear caused by grinding only plays a minor role

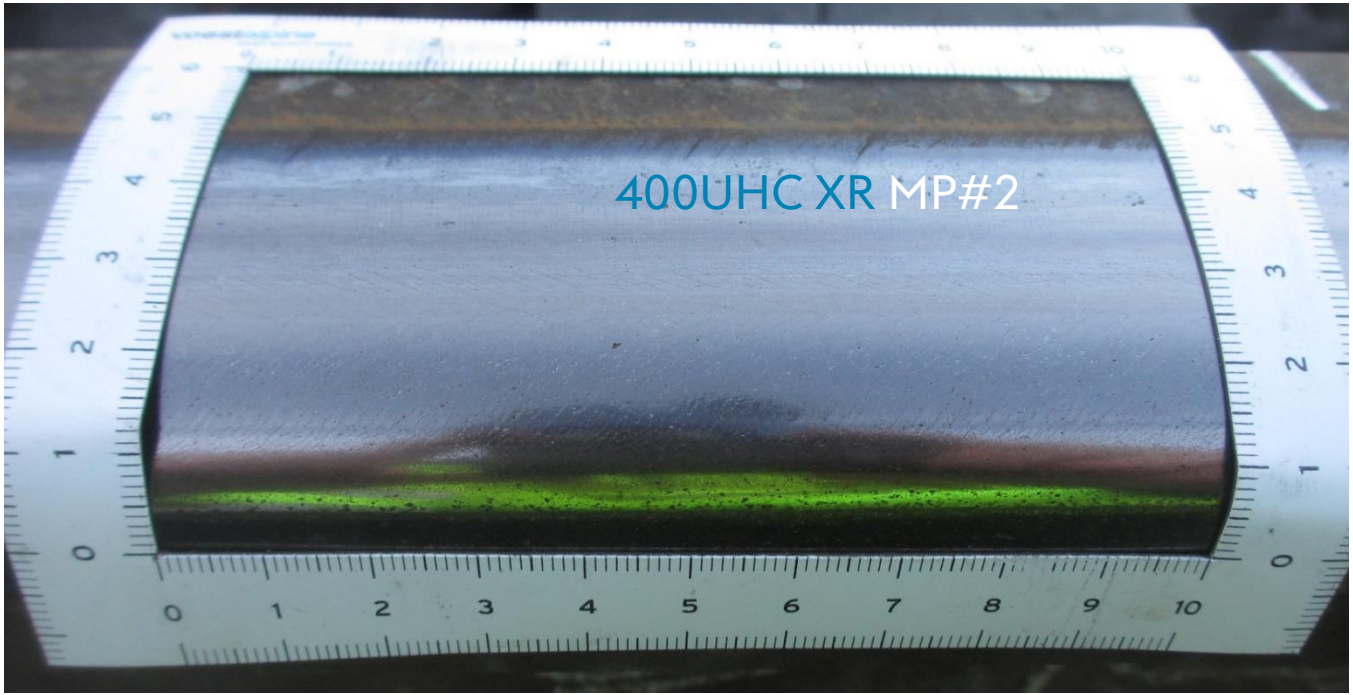
Wear (Post Grind Autumn 2022)

Total Comparison T Wear (Natural <> Artificial Wear)



400UHC® XR HSH® RCF Behaviour with a skipped grinding cycle

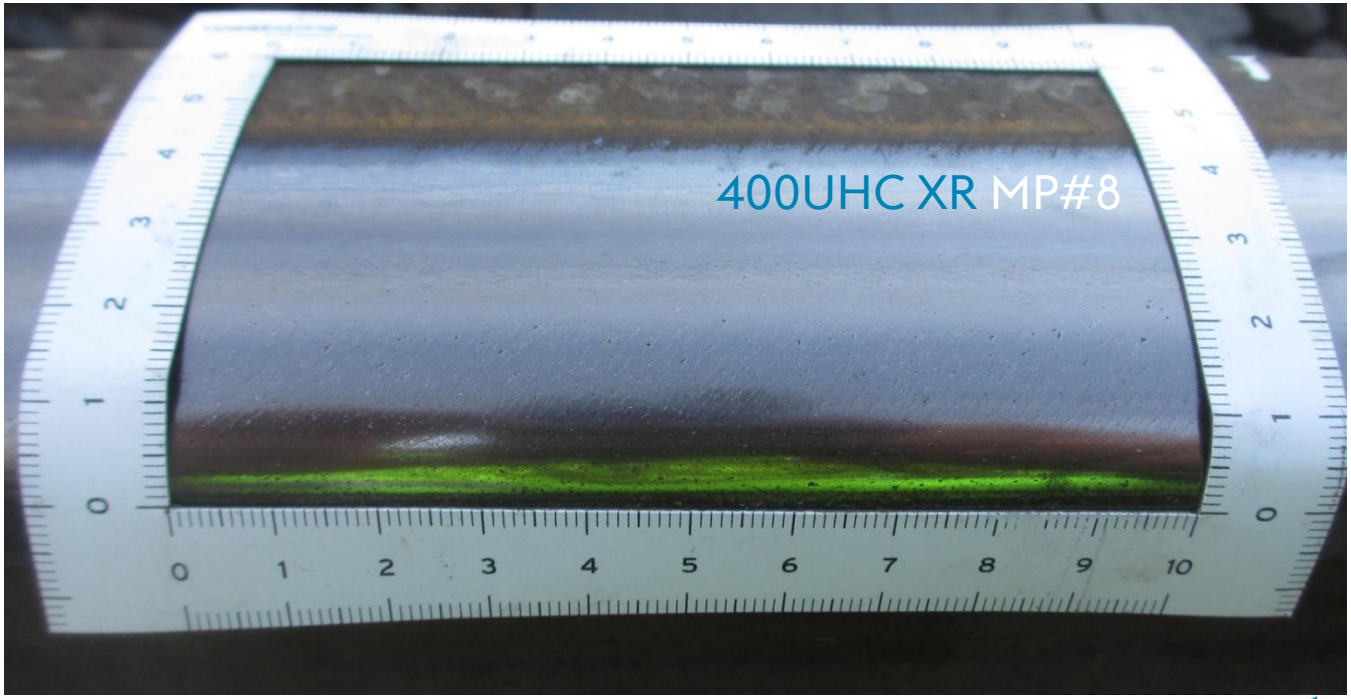
After approx. 32MGT (Autumn 21- Autumn22)



400UHC® XR HSH® RCF Behaviour with a skipped grinding cycle

After approx. 32MGT (Autumn 21- Autumn22)

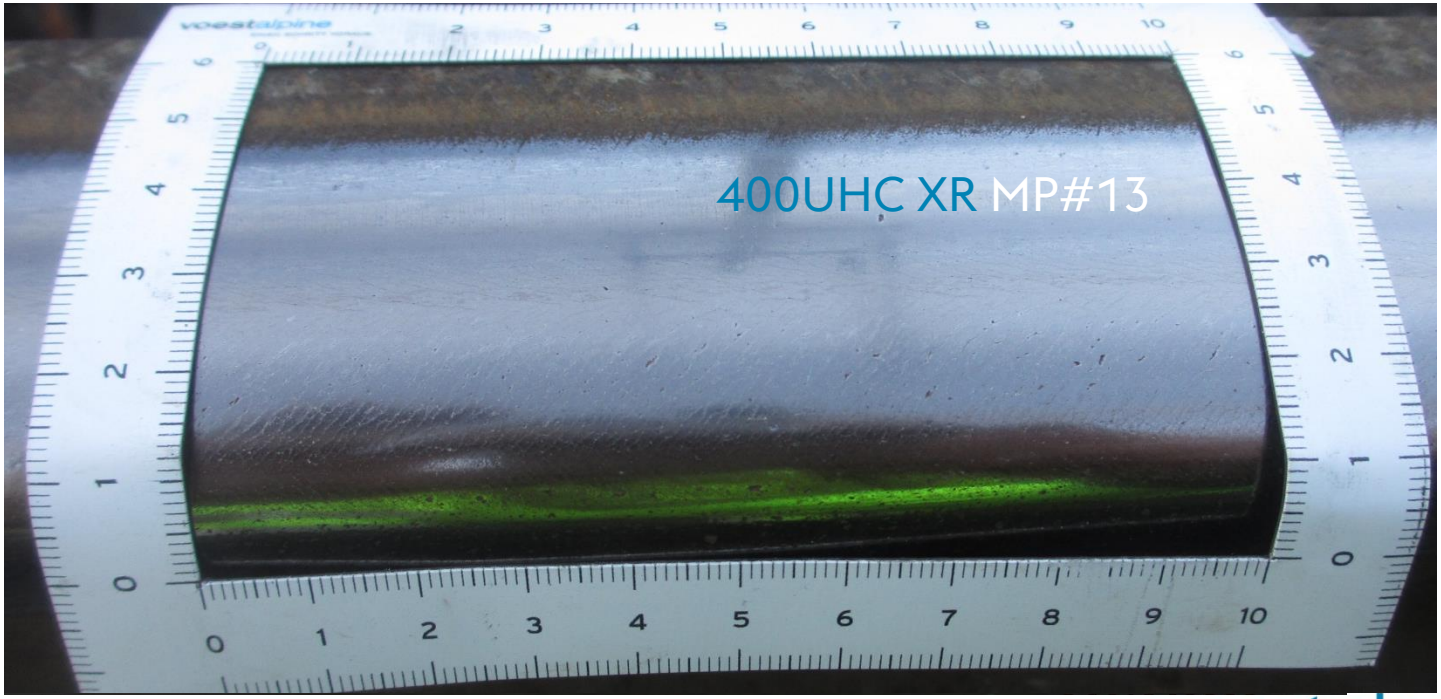
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400UHC® XR HSH® RCF Behaviour with a skipped grinding cycle

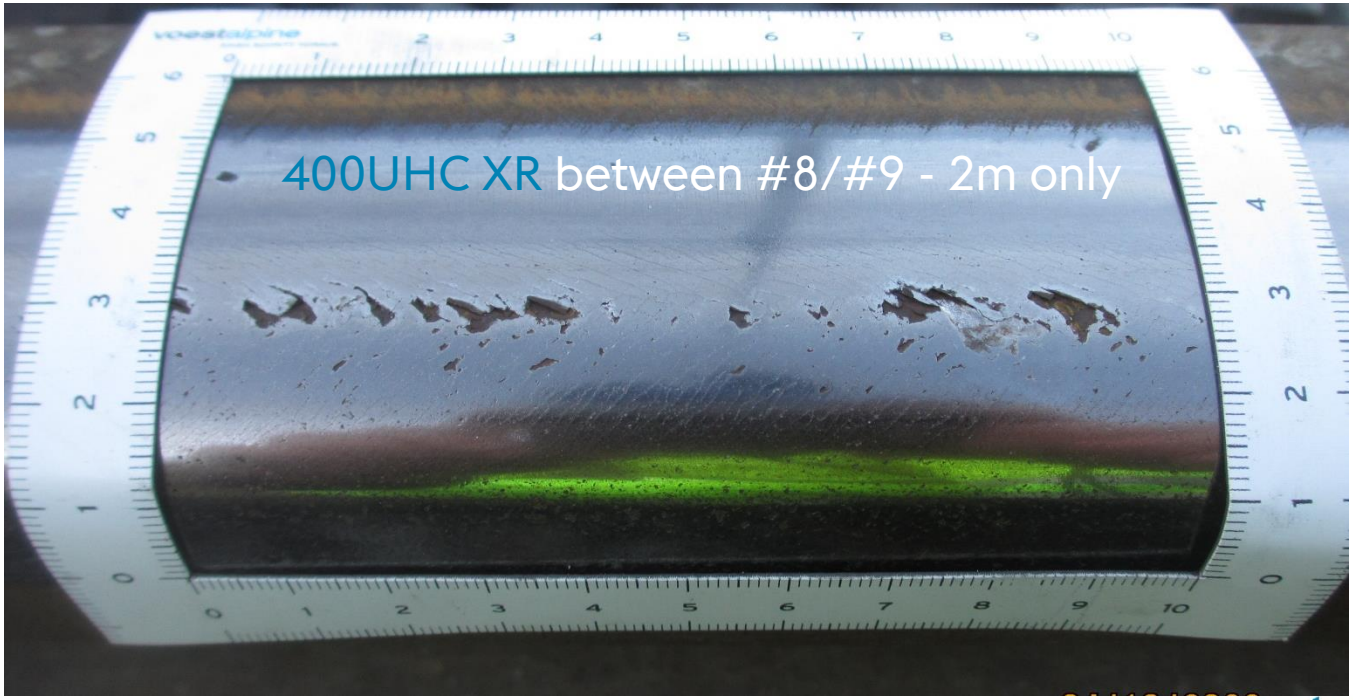
After approx. 32MGT (Autumn 21- Autumn22)



400UHC® XR HSH® RCF Behaviour with a skipped grinding cycle

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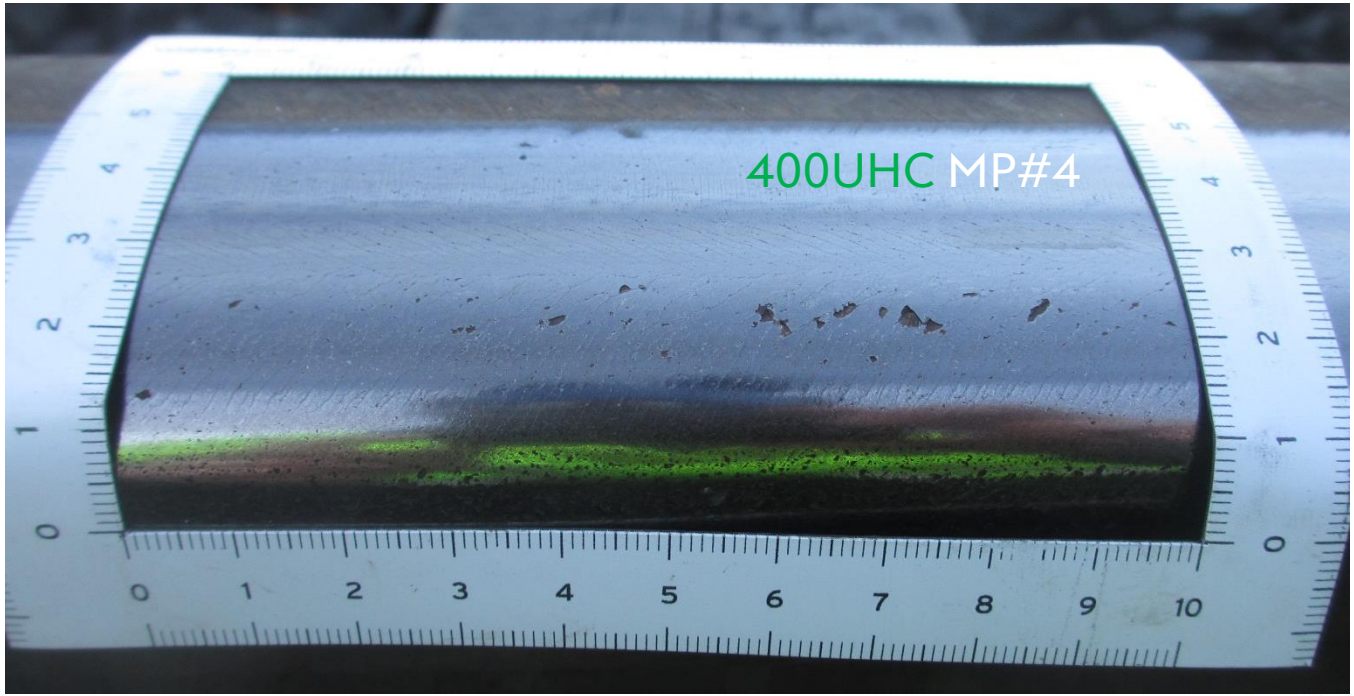


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400UHC® HSH® RCF Behaviour with a skipped grinding cycle

After approx. 32MGT (Autumn 21- Autumn22)

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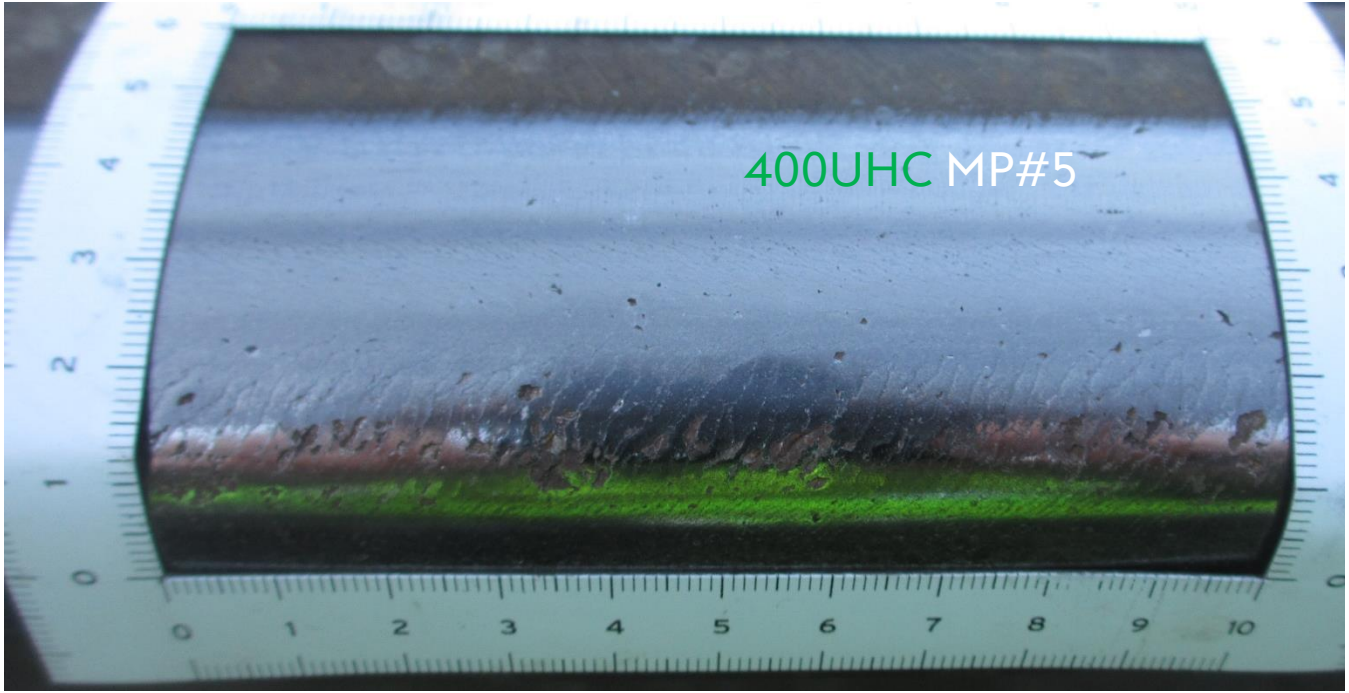


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400UHC® HSH® RCF Behaviour with a skipped grinding cycle

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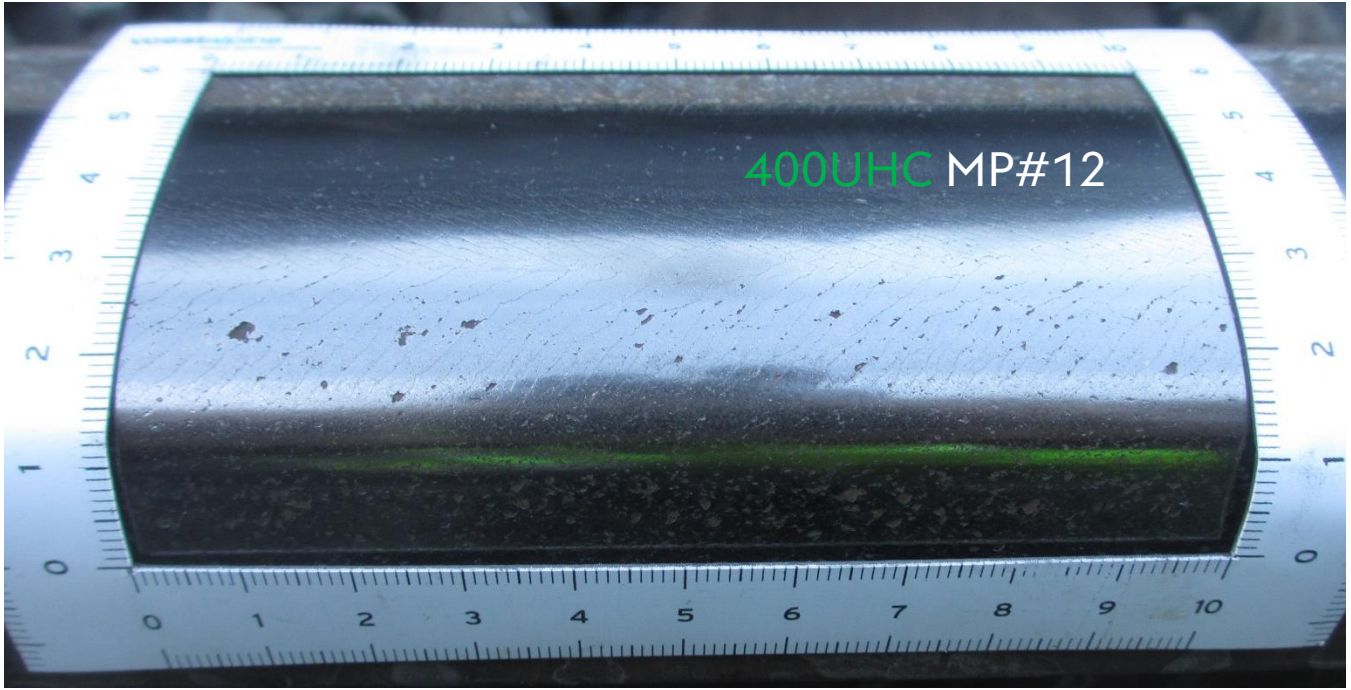


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400UHC® HSH® RCF Behaviour with a skipped grinding cycle

After approx. 32MGT (Autumn 21- Autumn22)

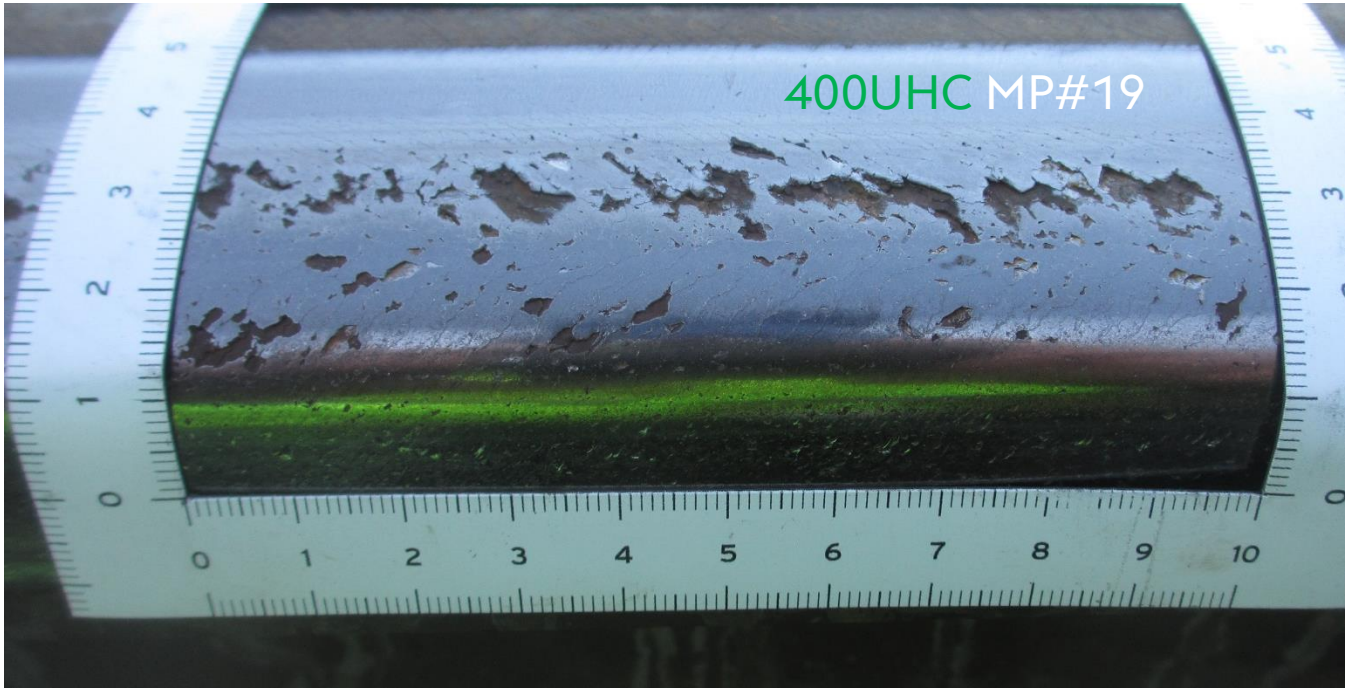
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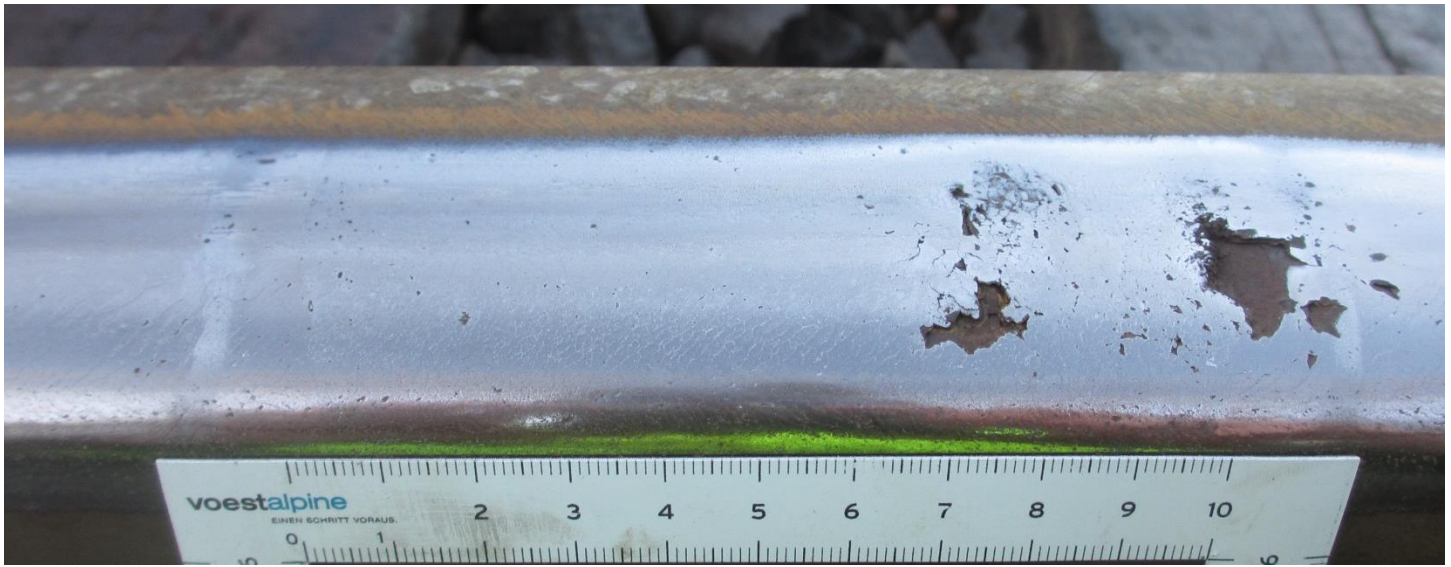
400UHC® HSH® RCF Behaviour with a skipped grinding cycle

After approx. 32MGT (Autumn 21- Autumn22)



RCF Behaviour Weld

After approx. 32MGT (Autumn 21- Autumn22)



400UHC® HSH® RCF Behaviour with a skipped grinding cycle

Post – grind Autumn22

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Due to no grinding in spring 2022:

>> **Head Checks could not be removed completely** during grinding campaign in autumn **(Grinding depth km 9,448: 0,48mm)**

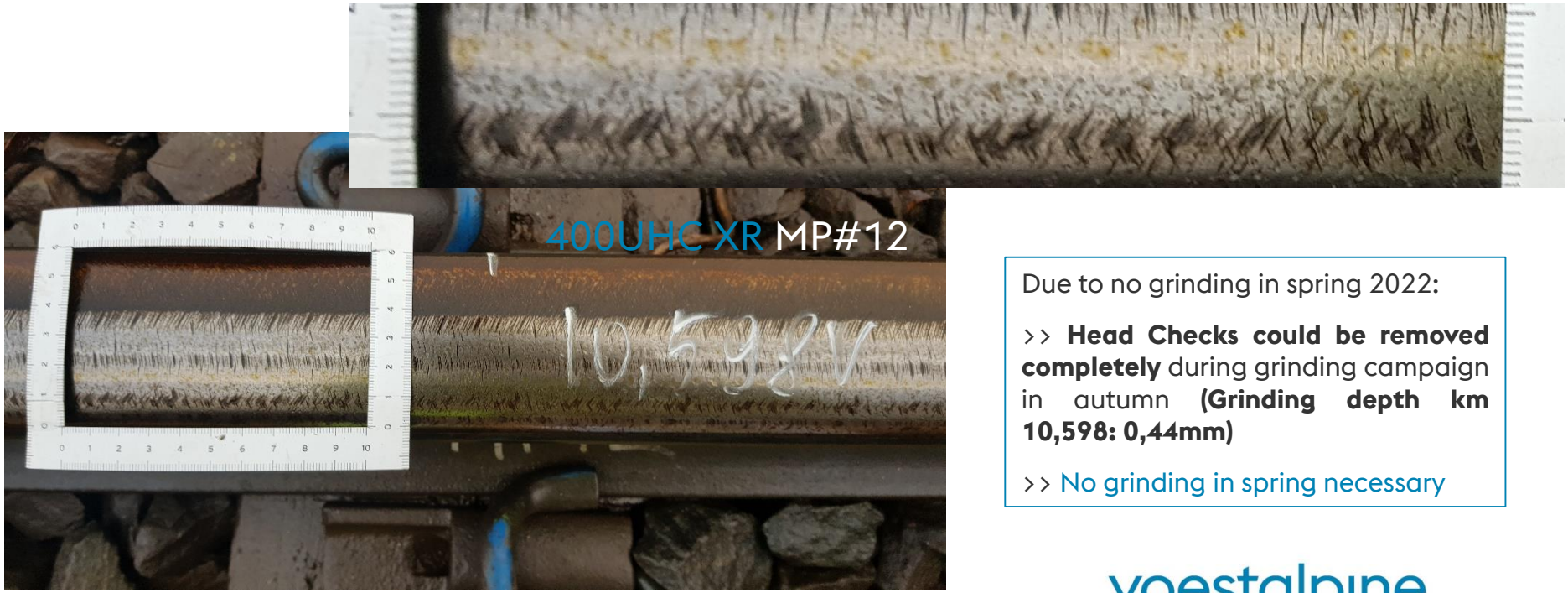
>> Grinding in spring necessary

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400UHC® HSH® RCF Behaviour with a skipped grinding cycle

Post – grind Autumn22

RAILWAY SYSTEMS



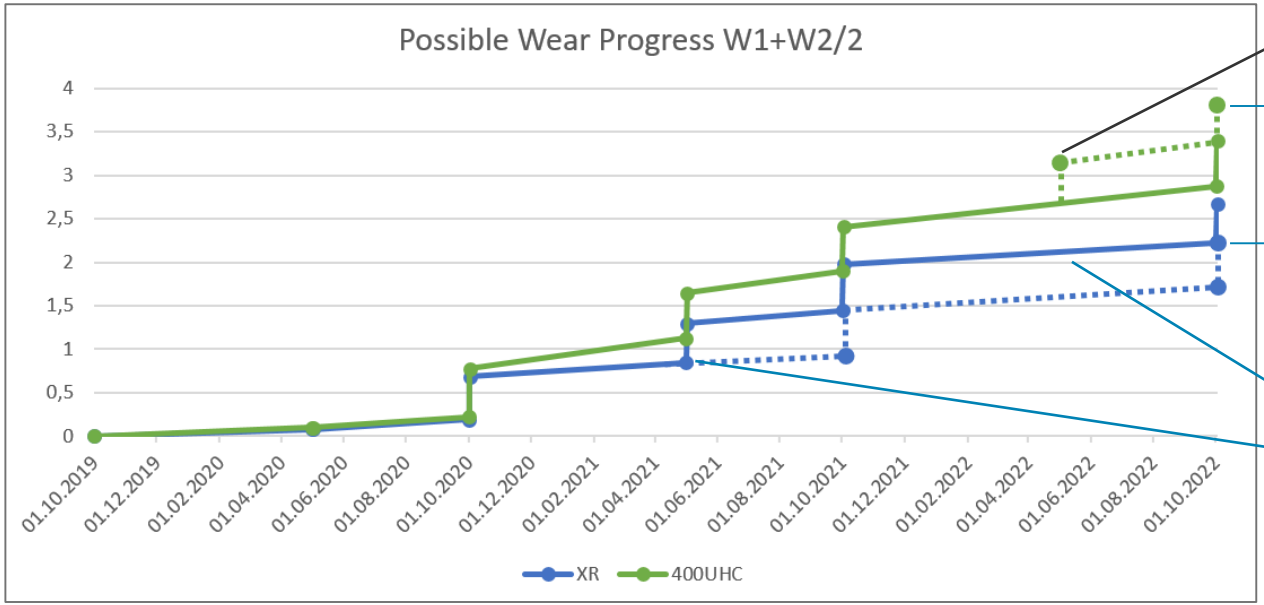
Due to no grinding in spring 2022:

>> **Head Checks could be removed completely** during grinding campaign in autumn **(Grinding depth km 10,598: 0,44mm)**

>> No grinding in spring necessary

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Possible T Wear progress by reducing grinding



400UHC: Standard grinding 2 times/year required

40% less T wear possible if grinding is reduced and due to higher wear resistance of XR grade

XR: No grinding necessary in spring because of better RCF resistance

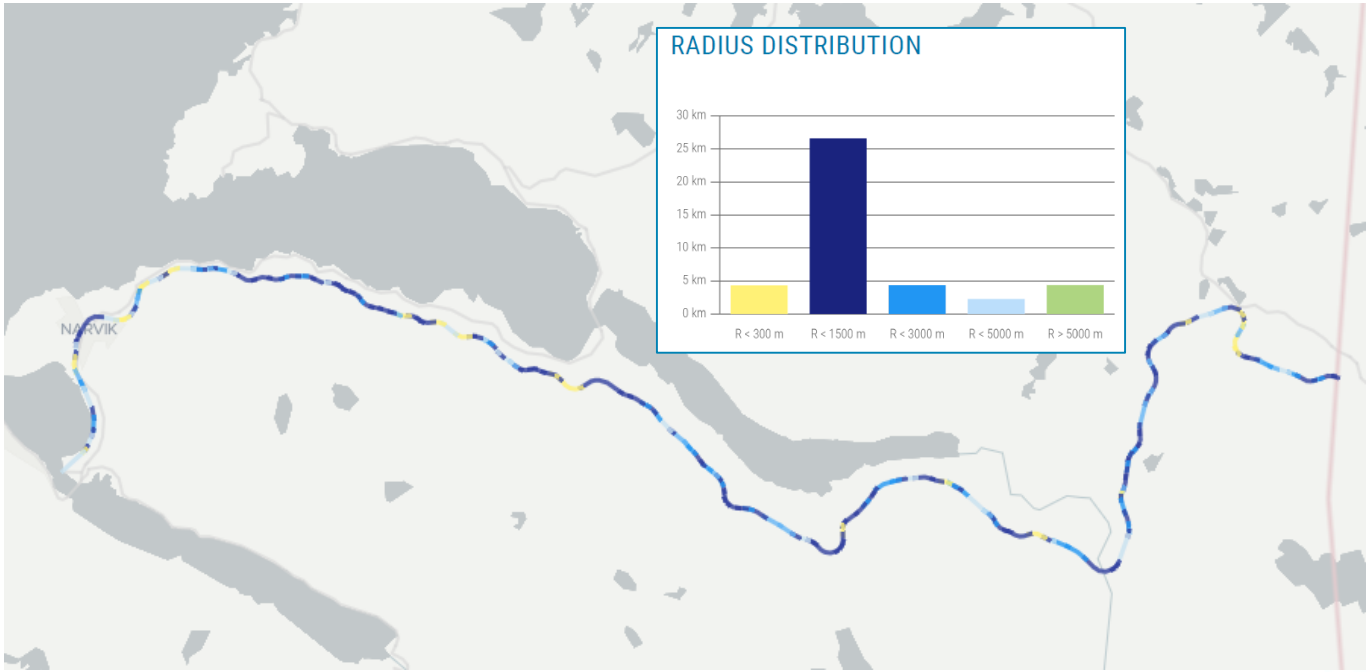


LCC - Assessment

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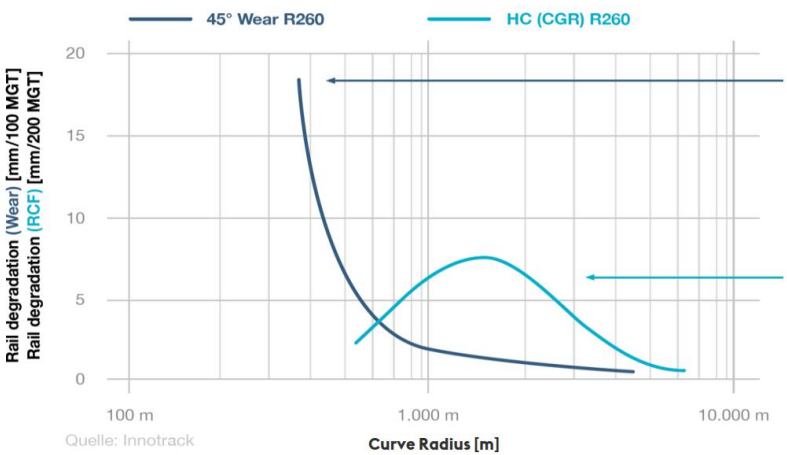
LCC Assessment - Ofotline



- Based on OSM Data and a special software the LCC costs for the whole Ofotline beginning from SWE/NO border to Narvik have been calculated
- All curves with different radii are considered within the calculation

LCC Assessment – Ofotline

Frame Conditions – Rail Degradation Mechanismen



Quelle: Innotrack



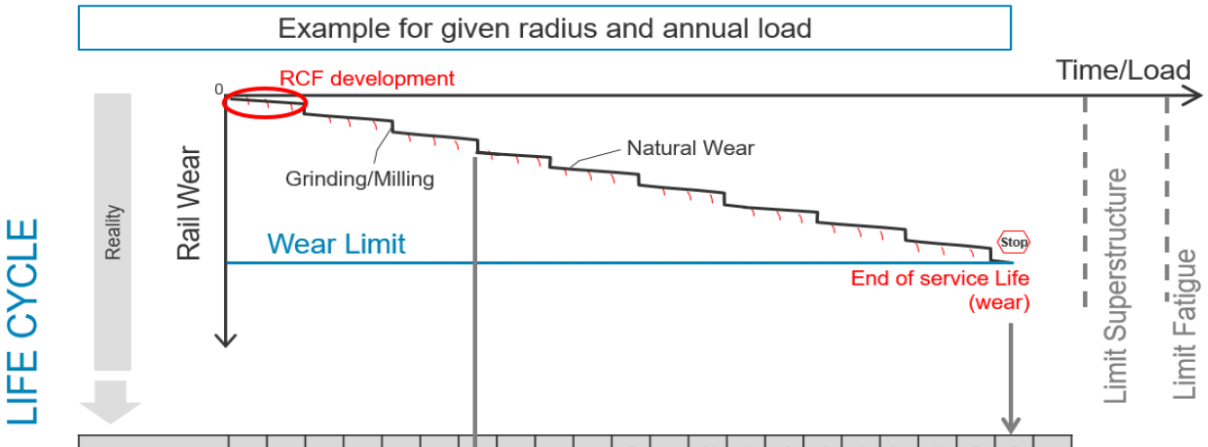


Relevant rail degradation mechanisms for rail renewal and maintenance

The basis for the calculation were the measurements of the curves P1 (XR) and B1ref (UHC)

LCC Assessment – Ofotline

Frame Conditions – Life Cycle Modeling in a Curve

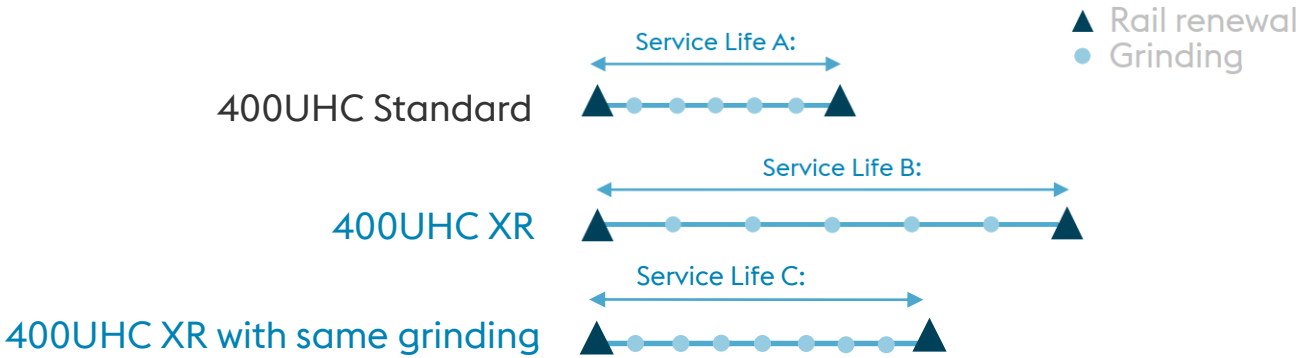


Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	...
Rail exchange	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	...
Grinding	-	-	1	-	1	-	1	-	1	-	1	-	1	-	1	-	1	-	1	-	-	...
Op. Hindrance Costs	1	-	1	-	1	-	1	-	1	-	1	-	1	-	1	-	1	-	1	-	1	...

Operational Hindrance Costs are not considered in the calculation

LCC Assessment – Ofotline

Frame Conditions – Equivalent Annual Costs Calculation



Formulas

$$CRF = (1 + (IR - Infl.))^n * \frac{IR - Infl.}{(1+IR-Infl.)^n - 1}$$

TV:	Time Value
Infl.:	Inflation
IR:	Interest Rate
CV:	Cash value / cash equivalent
NPV:	Net Present Value
n:	Period under consideration

EAC = Average annual costs, considering inflation and interest rate.

- The equivalent annual costs can be calculated from the Net Present Value by using a Capital Recovery Factor (CRF)
- Equivalent Annual Costs can be directly compared.
- The Technology that leads to lower Equivalent Annual Costs is economically more advantageous.

LCC Assessment – Ofotline

Frame Conditions – Financial Data

- Rail Costs
  - 400UHC® HSH®: according to actual frame contract
  - 400UHC® XR HSH®: = price of 400UHC® HSH® + approx. 10%
- Costs for Grinding 65NOK/m track (assumption based on other railways)
- Rail replacement incl. Welding 2000NOK/m track (assumption based on other railways)
- Operational hindrance costs 0NOK (no data available)
- Period under consideration: 40years

LCC Assessment – Ofotline

» Comparison of 3 different rail grade strategies:

Current standard:
400UHC with 2 times grinding/year



400UHC XR with 1 time grinding/year

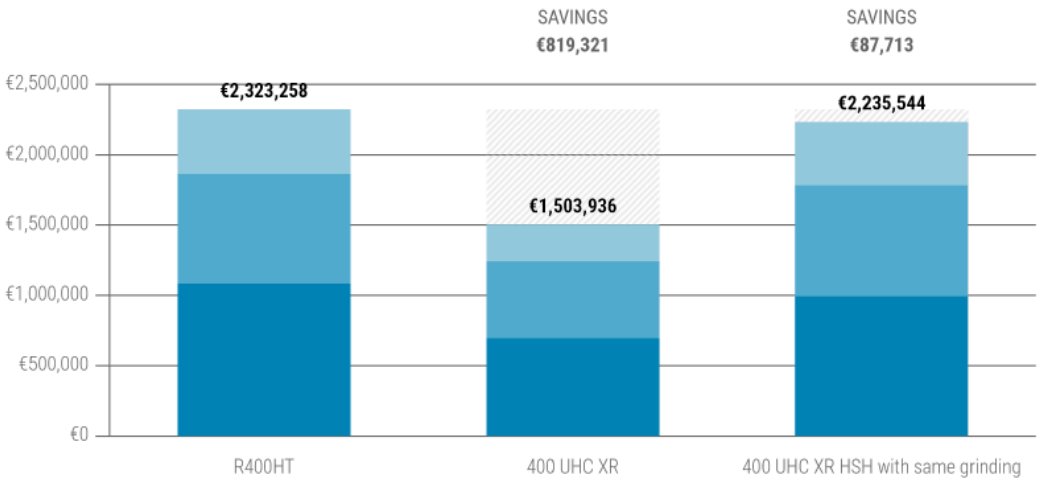


400UHC XR with same grinding as 400UHC (2times/year)



LCC Assessment – Ofotline

EQUIVALENT ANNUAL COSTS



SAVINGS BY USING STRATEGY 400 UHC XR

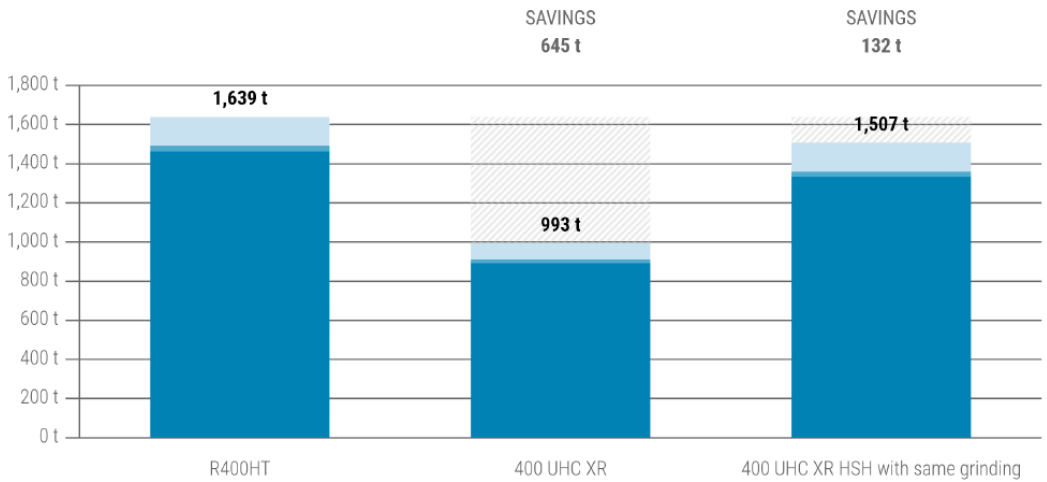
Rail installation	€388,343	35.9%
Rails	€233,428	29.8%
Grinding	€197,551	43.2%
Total	**€819,321**	**35.3%**

- By using the XR grade (for the whole track) with optimized grinding, the annual costs can be reduced by 35%
- By using the XR grade and doing the same grinding as now the annual costs can be reduced by 4%

LCC Assessment – Ofotline

GLOBAL WARMING POTENTIAL

ANNUAL CO_2-EQ. EMISSIONS



SAVINGS BY USING STRATEGY 400 UHC XR

Production	570 t	39.0%
Transport	11 t	39.0%
Maintenance and installation	64 t	43.6%
Total	**645 t**	**39.4%**

- By using the XR grade (for the whole track) with optimized grinding, 645to CO2/year are less emitted
- By using the XR grade and doing the same grinding as now 132to/year are less emitted (due to longer service life time and less rail demand)

Summary 400UHC XR HSH in service testing at Ofotline

- Wear and RCF Performance of 400UHC® XR in comparison to 400UHC® Standard significantly better
- Testwise skipping of one (spring) grinding cycle on 400UHC® Standard and 400UHC® XR revealed the potential to reduce grinding effort with 400UHC® XR significantly
- Welds show more pronounced HC´s
  - Change from 90HPW-E to Z140 will improve the situation
- LCC Calculation for the whole track showed the following results
  - By using the XR grade (for the whole track) and optimized grinding the annual costs can be reduced by 35%
  - By using the XR grade and doing the same grinding as now the annual costs can be reduced by 4%
  - By keeping the grinding interval (twice a year) and reducing the metal removal, the reduction is estimated to be in between
- Reduction of CO2 emissions by using 400UHC® XR possible because of longer service life time (less rail production and less transport emissions) and less grinding



Thank you!

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