TECHNISCHE UNIVERSITÄT MÜNCHEN

LEHRSTUHL UND PRÜFAMT FÜR VERKEHRSWEGEBAU
Univ. Prof. Dr.-Ing. S. Freudenstein

Report No. 2466 of 19th of September 2008

RESEARCH REPORT

Investigation on
FFU synthetic wood sleeper

(Komat GmbH, Austria)

Research Report No. 2466

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(Fa. Komat GmbH, Austria)

Dieser Bericht ist die englische Fassung des Originalberichtes in deutscher Sprache. Im Zweifel hat die deutsche Fassung Gültigkeit.
This is the english version of the original report in german language. In doupt the german version is valid.

1. GENERAL

By order of company *Komat GMBH, Austria,* extensive tests on *SEKISUI FFU-synthetic wood sleepers (Eslon Neo Lumber)* for railway construction had to be performed.

According to client statement, glass fibre strands get aligned and cast-in with polyurethane in the manufacturing process of the sleepers. After curing, the sleepers will be cut to millimetre precision.

Based on consultation with EBA (German Railway Authority), following test program was executed:

- Behaviour of the sleeper in repeated load test (fatigue test) under vertical and horizontal dynamic load. Bearing of the sleeper on ballast in accordance with DIN EN 13481-3 (Requirements for fastening systems on wooden sleepers).
- Sleeper screw piecing test to determine the tensile force in the screw depending on torque moment.
- Pull-out test on sleeper screws according to DIN EN 13481-2.
- Impact load test to simulate derailment according to DB-Standard (technical delivery terms)
- Electrical resistance test according to DIN EN 13146-5.
- Static and dynamic test on the sleepers according to DIN EN 13230-2.

In total 20 sleepers (in raw condition, without any drillings for screws) were delivered by the client. The dimensions of these sleepers (26 x 16 x 260 cm) are equal to conventional wooden sleepers. See appendix 1 for a drawing of the fastening system of the sleeper.
For execution of the tests with fastenings, six of the delivered sleepers were drilled for the sleeper screws by the client, as follows:

- Drilling diameter for sleeper screws: 19mm
- Widening of the holes in the upper 25 mm to a diameter of 24 mm.
- Depth of drilling: 14,5 cm
- The sleeper screws were torqued to a moment of 220 Nm. In advance, vaseline was applied into the drilling holes.

2. TEST EXECUTION

2.1 Repeated load test accorsing to DIN EN 13146-3 (February 2003) on sleeper No. 6

For appointment of the test loads in the fatigue test, the dynamic stiffness of the rail pad has to be determined in advance according to appendix B of DIN EN 13481-3. The dynamic stiffness between 20 kN and 95 kN at a load frequency of 5 Hz is higher than 200 kN/mm. With a dynamic stiffness > 200 kN/mm the rail pad is classified “stiff”. (On the secure side, the elasticity of the sleeper is not taken into account!)

Based on the dynamic stiffness the test load and position derive from table 2 of DIN EN 13481-3. The test parameters for one fastening system are as follows:

Upper load:	**$P_V/\cos\alpha = 83$ kN**
Angle of Inclination of load:	**$\alpha = 33°$**

The head of the rail has to be milled for the test to a milling value of **X = 50 mm**.
The test setup is in accordance to figure 3b of DIN EN 13146-4 (see pictures in attachment 1.1).

Executing the test on two fastening systems (one complete sleeper), the upper load in the test is 2 x P_v = 140 kN and the lower load is 10 kN at a load frequency of 3 Hz. According to table 1 of DIN EN 13481-3 the in-situ reference values, simulated by the repeated load test over 3 million load cycles at a load frequency of 3 Hz, are 225 kN axle load and a curve radius of the railtrack >150m.

The Appendices 2a to 2d show the deflections of the fastening within the test. Measurement of the displacements was done by dial gauges according to figure 5 of DIN EN 13146-4. The standards DIN EN 13481-3 and DIN EN 13146-4 define no requirements regarding the displacements and deflections in the fatigue test. See table 1 of this report for determined horizontal railhead displacement under load after the fatigue test.

Table 1:

	resilient railhead displacement		**permanent railhead displacement**	
fatigue test	right fastening	left fastening	right fastening	left fastening
After 3 million load cycles	2.12 mm	1.71 mm	0.42 mm	0.29 mm

According to existing experiences the shown values are within the permissible range.

Additionally the horizontal and vertical movement of the base plate (fieldside) was measured to a resilient vertical deformation of 0.23 mm respectively a permanent vertical deformation of 0.14 mm towards the sleeper. Horizontal movement of the base plate was 0.2mm on average.

Visual detection of the bottom side of the sleeper after removing from the ballast showed only marginal pressure marks on the bottom.

An additional test phase with increased temperature of 48°C was executed on the same sleeper and fastening. Within 1.28 million load cycles displacements occurred as shown in table 2. The appendices 3a to d show the recorded deflections during the test at T = 48°C.

Table 2:

	resilient railhead displacement		**permanent railhead displacement**	
fatigue test	right fastening	left fastening	right fastening	left fastening
After 1.28 million load cycles	2.05 mm	1.93 mm	0.41 mm	0.48 mm

Values in table 2 are in the same range as in the fatigue test at ambient temperature (table 1). It can therefore be inferred that the mechanical behaviour of the system is only marginally affected by increased temperature. After the test, the base plates were removed and fastening torque was determined again (M = 180 Nm, average values of 8 Schrauben). The upper surface of the sleeper showed an impression of the base plate (see photo in attachment 1.2) with permanent deformations of 0.7 mm (fieldside of the rail), respectively 0.3 mm (in-side of the rail). The bottom side of the sleeper showed only light pressure marks.

2.2 Tensile force in the sleeper screws in relation to torque moment and time

For this test recesses for application of strain gauges were milled into the shaft of two sleeper screws on two opposite sides. Subsequently, the sleeper screws were calibrated in a centric pull-out test device in order to get a correlation between tensile force and strain of the screw.
The base plate was mounted onto sleeper no. 7, a torque moment of 200 Nm and respectively 250 Nm was applied in steps (see photos in attachment 2).

Please see summarized results in table 3.

Tabelle 3:

	First test		Second test	
Torque moment	Resting time	Tensile force	Resting time	Tensile force
200 Nm	t = o	17 – 21 kN	t = o	21 kN
200 Nm	t = 40 min	16 – 17 kN	t = 40 min	18 kN
250 Nm	t = o	25 kN	t = o	25 kN
250 Nm	t = 40 min	20 kN	t = 40 min	22 kN
250 Nm	t = 16 h	19 kN	t = 3 days	20 kN

2.3 Pull-out test

During pull-out test, a centric tensile force is applied to sleeper screws and measured by an interconnected load cell (see photos attachment 2). Tests were conducted based on DIN EN 13481-2, attachment A, on all eight sleeper screw drillings of one synthetic sleeper (no. 5).

Load was increased continuously until the screw was pulled out. Please see table 4 for the recorded maximum pull-out force.

Table 4:

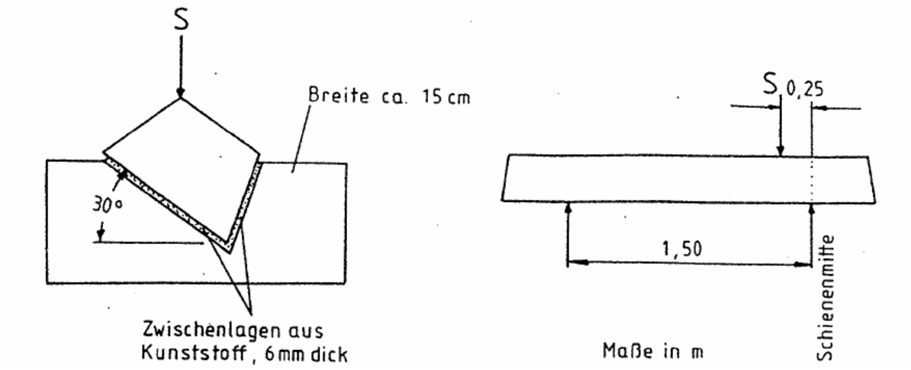
Test No.	Pull-out force [kN]
1	73,4
2	71,3
3	72
4	60
5	60
6	50
7	47
8	60

Average pull-out force is 61 kN. Previous pull-out tests on sleeper screws on wooden sleepers showed pull-out forces of approx. 35 kN [Research Report No. 1687, dated June 30.,1997, not released].

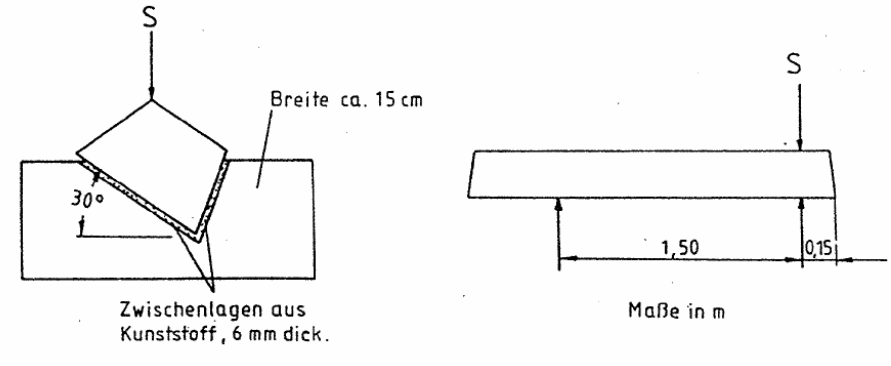
2.4 Impact test / Derailment test

Sleeper derailment resistance is checked through an impact load test in accordance with DB TL (German Railway technical delivery specifications for concrete sleepers – Basic Guideline for Dimensioning, Construction and Approval Procedures). Each test sleeper has to be subjected to impact load test I and II. A tup (dead weight 5 kN) with a wheel-flange shaped blade is dropped twice per test from a height of 75 cm onto the impact position indicated below on the edge of the sleeper. The sleeper is positioned at a slope of 30°. During testing, the sleeper is placed on a 6mm elastic pad.

Impact test I / Derailment test I: Impact position 25 cm from center of rail, positioned towards sleeper center.



Impact test I / Derailment test II: Impact position at 15 cm distance to sleeper edge.



Three sleepers without drilling holes were subjected to impact testing (number S7, S8 und S9). The absence of the drillings does not affect the test results (impact load is not applied at fastening positions). Please see attachments 3.1 to 3.5 for photo documentation. The tested sleepers show no warping caused by impact. Damages in impact test I are limited to a small area near impact position, in impact test II fibres were detached up to sleeper front end.

In impact test I (25 cm from central fastening positioned towards sleeper center) fibres at impact area are merely cut through to a depth of 25 mm. Surface deformation at impact area in the shape of a wheel flange (resp. the edge of the impact tub). Length of surface indentation is approx. 90 mm at most. Behaviour is comparable to that of wooden sleepers.
In impact test II a wedge-shaped cutout (15 cm distance from sleeper front end) is removed from the sleeper. The dimensions of the cutout piece match the length of the surface indentation (70 to 90 mm). The horizontal crack runs from the point of impact to the front end of the sleeper (length: 15 cm).

In service, sleepers are not treated by bending in the area of the wedge-shaped cutout. Consequently, the reduction in diameter in this area has no effect on sleeper bending behaviour.

Prior to and after each applied impact, each sleeper was checked for deformation with a graduated measuring rod. A change in track gauge (test criterion) can solely occur as a consequence of permanent sleeper deformation. The sleepers did not show any rotation or warping. Thus, track gauge remained constant.

An additional requirement of this test is, to show only sporadic continuous cracks (transverse to sleeper direction) and scattered spalling down to the reinforcement as a result of impact load (as mentioned previously, the above specification applies to concrete sleepers). Cause of the fact, that the synthetic wood sleeper does not feature any reinforcement, these criteria cannot be applied.

In accordance with the avertable evaluation criteria, sleeper function (load capacity and track gauge) remained unaffected. The horizontal crack inflicted by impact test II invariably ran from the point of impact to the front end of the sleeper, but never to the rail fastenings. Therefore, it can be expected that the base plate screw connections are not affected by any such load.

2.5 Determination of the electrical resistance between the rails (DIN EN 13146-5)

As in all further tests, the base plate of this “KS-fastening” is mounted onto the sleeper without a plastic pad below. Before setting sleeper screws, vaseline is applied to dowel holes. The fastener is set to an air gap of 1.0mm between the center loop of the fastening clip and the rail foot.

The standard **DIN EN 13146-5** “Determination of electrical resistance” demands to calculate the electrical resistance as mean value of three measurements. Within this test, the electrical resistance between two short lengths of a rail (approx. 0,5 m, type 60E1), fixed on the sleeper by the fastening components, has to be measured, while the whole sleeper and fastenings are sprayed with water at a controlled rate of 7 ±1 l/min from each of 4 nozzles for 2 minutes. By the correction factor K_γ the conductivity of the used water is taken into account. The conductivity γ [mS/m] of the water shall be between 20 and 80 mS/m. It has to be measured and corrected to a temperature of 25 °C. The test stand is compliant to figure 2 in EN 13146-5.

During the test (Duration: 15 minutes) the sleeper is insulated to the ground. An alternating voltage of 30 V AC and 50 Hz, which is impressed on the two rails, and the resultant current flow will be recorded (device: bmc PCI-Base 300).

By the correlation $R = U/I$ the minimum electrical resistance R_γ between the two rails will be evaluated. The corrected resistance will be calculated by the following equation:

$R_{33} = R_\gamma * K_\gamma$
with $K_\gamma = 0{,}03 * \gamma$

The specification demands a minimum electrical resistance of 5 kΩ as mean value of three measurements. Table 5 shows the results of the test. See appendix 4 for the recordings of the test.

Table 5: Electrical resistance of the synthetic wood sleeper with KS-fastening

		Test 1	**Test 2**	**Test 3**
Date		10.07.2008	11.07.2008	12.07.2008
R_γ	**[kΩ]**	38,9	63,8	57,7
γ	[mS/m]	44,4	45,3	44,6
K_γ		1,332	1,359	1,338
R_{33}	**[kΩ]**	51,8	86,7	77,2
Mean value R_{33}	**[kΩ]**	**71,9**		

Hence, the requirement of EN 13481-5 has been easily met.

2.6 Static test in sleeper center (Sleeper No. 1)

In order to investigate sleeper behaviour when subjected to bending load, a static test was conducted on the center of the sleeper on the basis of DIN EN 13230-2.

Test setup is shown in attachment 4. Bearings clearance was 1.5 m, load plate width was 100 mm. The initial test load was set to 20 kN. Subsequently, the load was increased in steps of 5 kN, while sleeper bending was registered by four dial gauges. Appendix 5 shows the values of sleeper bending up to a load of 135 kN, corresponding to a torque moment of 47 kNm. Based on the measured bending value the Young's Modulus E was determined using the following equation:

$$E = \frac{P \cdot l^3}{48 \cdot I \cdot f}.$$

E = Young’s Modulus E N/mm²
l = Bearings clearance: 1500 mm
I = Torque of Inertia [mm^4]
f = Bending deflection under load [mm]

Thus, Young’s Modulus E of the synthetic wood sleeper under bending load is approx. 7000 N/mm².

Up to a load of 240 kN, corresponding to a bending tensile strength of 74 N/mm² on the bottom of the sleeper, no crack was detected within the bending tensile area. Strong plastic deformations and superficial fissures were detected within the bending pressure area (upper side of the sleeper), although it must be noted that generally, deformations of this scope do not occur in service.

The same test (265 mm x 160 mm) was conducted concurrently with a wooden sleeper (beechwood 265 mm x 160 mm). Please see results in appendix 5. According to the test results, the wooden sleeper failed at a load of 80 kN within the bending tensile area.

2.7 Fatigue test in sleeper center (sleeper No. 2)

In order to investigate the behaviour of the synthetic sleeper under repeated load, a fatigue test according to DIN EN 13230-4 was conducted. Please see the picture in attachment 5 for the test setup. During the entire testing procedure, sleeper bending and strain on the bottom side of the sleeper in the area of maximum torque moment were registered.
The bearings clearance was 1.5 m during testing, load application was carried out according to DIN EN 13230-4 using a load application hinge with width 100 mm.

Load was applied up to 100 kN. Subsequently, the fatigue test was conducted with the following basic conditions:

Upper test load	P_o = 86 kN
Lower test load	P_u = 21.5 kN
Frequency	f = 2 Hz.

The upper load corresponds to a torque moment of 30 kNm. This value is consistent with the test torque for switch sleepers in accordance with DBS 918 143. This means, that the test conditions were extremely critical
During fatigue testing with 2.5 million load cycles no damages were detected on the sleeper. Appendix 6 shows deflection prior to the fatigue test and after 2.5 million load applications. Thus, resilient deflection after 2.5 million loads is only 0.4mm greater than at the start of the test.

Appendix 7 shows deformations through static load during the fatigue test. It was observed that during the entire testing procedure, deformation remained nearly constant, this means that there were no visible signs of fatigue. Measured strains on the bottom side did not vary after 2.5 million load cycles. Finally, the sleeper was subjected to a load of 175 kN, corresponding to a bending tensile stress of 56 N/mm², whereat no cracks appeared in the tensile area (bottom side). Plastic deformations were visible in the compression area (upper side).

2.8 Fatigue test on rail seat (sleeper No. 4)

According to test 2.7, there is no failure due to high bending tensile stresses. The fatigue test on rail seat (compression load) was supposed to indicate sleeper behaviour under high pressure.

The fatigue pressure test on the rail seat was conducted according to DIN EN 13230-2 (concrete sleepers). According to the standard, a bearings clearance of 600 mm was selected. Load application took place over the base plate with completely mounted rail fastenings. An upper load of 150 kN was selected for the fatigue test. Therefore, testing procedures also incorporated the most severe conditions, such as incorrect track setting, inaccurate load distribution of the rail, stiff bearings and a high dynamic allowance to an axle load of 250kNm.

Please see attachment 6 for a photo of the test setup. The test was conducted under the following basic conditions:

Upper test load	$P_o = 150$ kN
Lower test load	$P_u = 30$ kN
Frequency	f = 5 Hz.

During fatigue testing with 2.0 million load cycles, no damages were detected on the sleeper.

Appendix 8 shows bending prior to and after the fatigue test. Therefore resilient bending (after 2 million load cycles) is 0.2 mm higher than before the start of the test.

Subsequently, the base plate was removed. On the surface of the sleeper (below base plate) permanent deformations of approx. 1.0 mm were detected. No further damages were noticed.

2.9 Static pressure test (on second railseat of sleeper No. 4)

In order to analyze sleeper behaviour under vertical load, the sleeper was installed on an even surface, then vertical pressure was applied onto the completely mounted fastening system. Up to a load of 150 kN no permanent deformation was detected. Appendix 9 shows permanent deformation and corresponding load in the fastening system.

Thus, a load of 300 kN (on one rail seat) causes permanent deformation of a maximum of 0.8 mm below the base plate (see photos in attachment 7). As pointed out in 2.8, the load on one rail seat by an axle load of 250 kN is 150 kN in case of most severe conditions.

2.10 Static bending of sleeper at ambient temperature and at T = -10°C

Both tests were conducted with a bearings clearance of 1.0 m. For the test at temperature below zero, the sleepers were stored in a climate-controlled environment at T= -20°C for two days. During testing, sleeper temperature was checked via a 5cm deep drillinghole placed on the face side of the sleeper. Between removal of the sleeper from the climate–controlled environment and the test execution, the sleeper was warming up caused by an ambient temperature (RT) of about + 23°C. The average temperature of the sleeper whilst test execution (during three static load cycles with recurrent dial gauge readings) is therefore indicated at T = -10°C .

Appendix 10 shows the deflection of sleeper No. 3 at T = RT by loading up to 200 kN (bearings clearance: 1,0 m).
Appendix 11 (sleeper No. 11) demonstrates bending at test temperature T = -10°C and otherwise ancillary conditions.

Test results confirm that deformation behaviour under applied bending moment is only marginal dependent on temperature. The sleeper shows no signs of embrittlement at low temperatures. A comparison of deformation in the first and third load cycles does not show any significant differences. This leads to the conclusion that fibres will not break when subjected to the applied bending moment - even at low temperatures.

3. SUMMARY

The company **Komat GmbH, Austria**, ordered extensive testing of the Sekisui FFU synthetic wood sleeper (Eslon Neo Lumber) for application in rail tracks. According to client statement, glass fibre strands get aligned and cast-in with polyurethane in the manufacturing process of the sleepers. After curing, the sleepers will be cut to millimetre precision.

Based on consultation with EBA (German Railway Authority), following test program was executed:

- Behaviour of the sleeper in repeated load test (fatigue test) under vertical and horizontal dynamic load. Bearing of the sleeper on ballast in accordance with DIN EN 13481-3 (Requirements for fastening systems on wooden sleepers).
- Sleeper screw piecing test to determine the tensile force in the screw depending on torque moment.
- Pull-out test on sleeper screws according to DIN EN 13481-2.
- Impact load test to simulate derailment according to DB-Standard (technical delivery terms)
- Electrical resistance test according to DIN EN 13146-5.
- Static and dynamic test on the sleepers according to DIN EN 13230-2 (standard for concrete sleepers).

During fatigue test (effect of repeated loading -chapter 2.1) at T = RT (ambient temperature) und T = +48°C no significant damages to sleeper or fastenings were detected.

The tensile force of the sleeper screws (chapter 2.2) against an externally applied pulling force only decreased marginally during a longer time span.

Sleeper screw pull-out load (chapter 2.3) showed higher values than those recorded in previous tests on wooden sleepers.

German Railway technical delivery specifications for concrete sleepers – Basic Guideline for Dimensioning, Construction and Approval Procedures

In impact test (chapter 2.4) in accordance with the technical delivery specifications of DB „German Railway technical delivery specifications for concrete sleepers – Basic Guideline for Dimensioning, Construction and Approval Procedures“, the sleeper merely showed a limited indentation caused by the impact test I (impulse in-side the rail). After impact test II (impulse fieldside of the rail) there was some chipping along the edge congruent with the depth of the indentation. Sleepers did not get warped as a result of impact testing, as the track gauge remained constant.

Electrical resistance between the rails (chapter 2.5), tested in accordance with DIN EN 13146-5, shows a markedly higher value of more than 70 kΩ. This result is very likely to comply to the required minimum resistance of 5 kΩ.

Bending test results (chapter 2.6 to 2.8) showed a very high bending tensile strength. The mechanical behaviour and the weight of the synthetic wood sleeper is identical to that of a regular wooden sleeper. Bending stiffness is higher than that of the classic beech sleeper, while bending tensile strength is significant higher. Therefore, the sleeper is able to resist to a significantly greater amount of resilient deformation without damages in shape of cracking.

During static pressure test (chapter 2.9), with applied load to the rail fastening on a rigid bedded sleeper, no plastic deformations of the sleeper surface were detected up to a vertical load on one rail seat of 150kN (maximal value for an axle load of 250 kN under most severe conditions).

Test of temperature dependency of sleeper deformation behaviour (chapter 2.10) showed no significant bending differences at T=RT and T= -10°C. Even at T= -10°C there is no noticeable brittleness due to temperature below zero. Deformation is almost pure resilient.

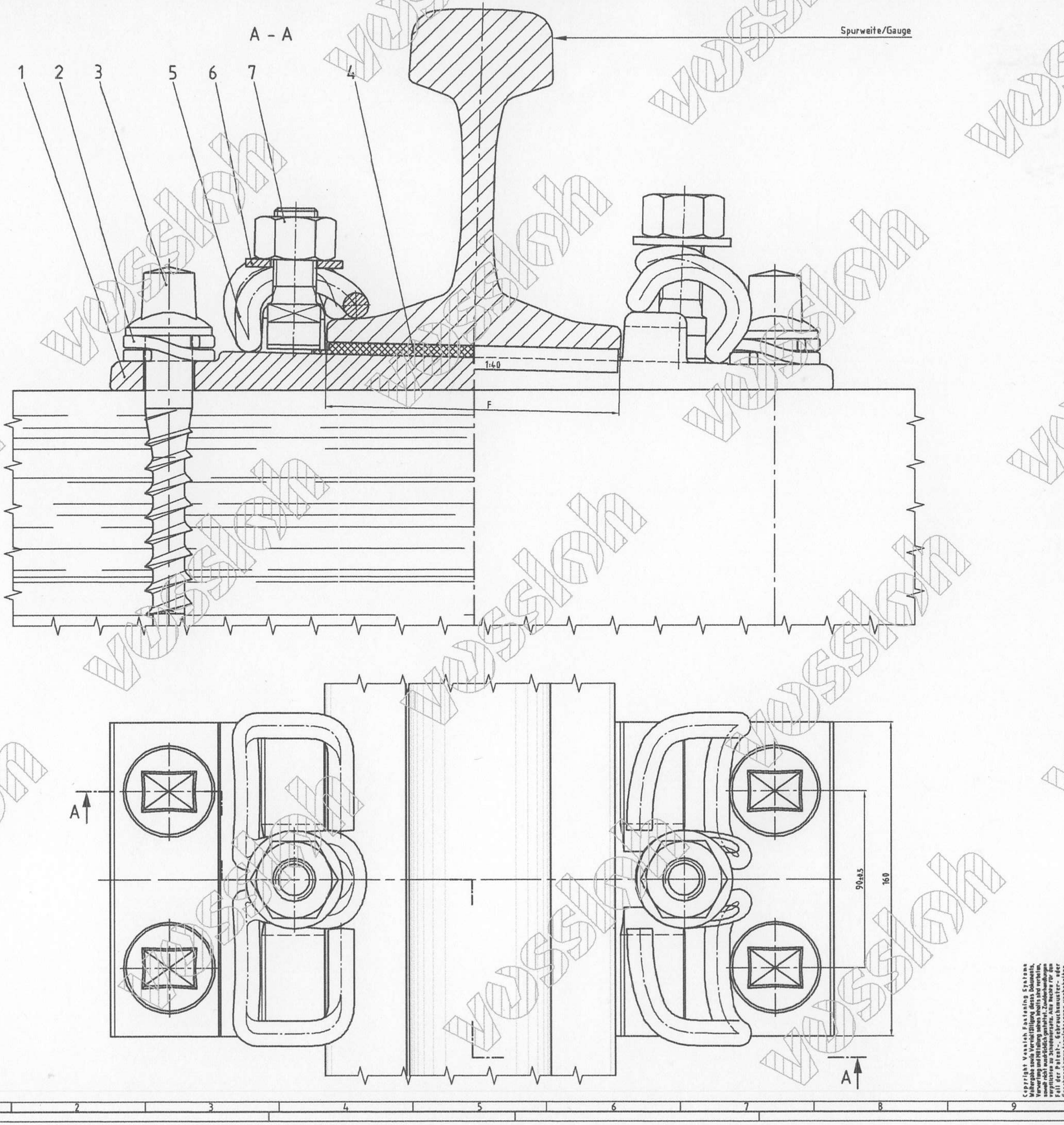
München, 19.09.2008

(Dr.-Ing. S. Freudenstein)
Univ.-Prof.

For performance and
evaluation of the tests:

(Dipl.-Ing. N. Maleki)

(Dr.-Ing. Ch. Simon)



Bemerkungen
Verspannen der Skl:
Die Einbaustellung ist erreicht, wenn die Mitteschleife den Schienenfuß berührt oder ein Luftspalt bis zu 2mm besteht.
Richtwert für das erforderliche Drehmoment: ca. 180-200 Nm.

Steifigkeit der Schienenzwischenlage c stat. ≥ 200 kN/mm, gemessen als Sekantensteifigkeit zwischen 18kN-68kN.

Remarks
Tightening of the tension clamp:
The tension clamp is correctly fitted if the middle bend has contact with the rail foot or an air gap up to 2 mm exists.
Standard value for the necessary torque: approx. 180 to 200 Nm.

Stiffness of rail pad c stat. ≥ 200 kN/mm, measured as secant stiffness between 18kN-68kN.

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Respect the industrial property rights!

Materialbedarf für einen Stützpunkt
Material for one rail seat

Pos. Pos.	Stück Pieces F=150	F=140	F=125	Benennung Designation	Zeichn.-Nr. Drawing No.	Werkstoff Material	Bemerkung Remarks
7	2	2	2	Hakerschraube Hs 32 $^{-55}$ mit Mutter T-head bolt Hs 32^{-55} with nut	1.1139	Stahl Steel	
6	2	2	2	Unterlegscheibe Uls 6 Washer Uls 6	1.1138	Stahl Steel	
5	2	2	2	Spannklemme Skl 12 Tension clamp Skl 12	1.1979	Federstahl Spring steel	
4	1	-	-	Zwischenlage Zw 687 Rail pad Zw 687	1.2154	Kunststoff Plastic	
4	-	1	-	Zwischenlage Zw 138/165/6 VH Rail pad Zw 138/165/6 VH	1.2155	Kunststoff Plastic	
4	-	-	1	Zwischenlage Zw 686 Rail pad Zw 686	1.2153	Kunststoff Plastic	
3	4	4	4	Schwellenschraube Ss 8 $^{-150}$ Sleeper screw Ss 8 $^{-150}$	1.0547	Stahl Steel	
2	4	4	4	Hochsp. doppelter Federring Fe 6-gerändelt Spring washer Fe 6-knurled	1.077zh	Federstahl Spring steel	
1	1	-	-	Rippenplatte Rph 6 $^{-160}$ Ribbed plate Rph 6 $^{-160}$	1.1808	Stahl Steel	
1	-	1	-	Rippenplatte UIC 54 $^{-160}$ Ribbed plate UIC 54 $^{-160}$	1.1808	Stahl Steel	
1	-	-	1	Rippenplatte Rph 1^{-160} Ribbed plate Rph 1^{-160}	1.1808	Stahl Steel	

Ind.	Änderung	Datum	Name	Gepr.
d	In CAD erstellt	22.12.14	Wrobl.	Böhm

CAD-Zeichnung nicht manuell ändern!
Maße ohne Toleranzangabe
Verwendet für

	Datum	Name	Maßstab	Werkstoff
Bearb.	22.12.04	Wroblewski		
Gepr.	22.12.04	Böhm		

vossloh Fastening Systems
Vossloh Fastening Systems GmbH, Vosslohstr. 4, D-58791 Werdohl

Vossloh Oberbau KS
mit Spannklemme Skl 12

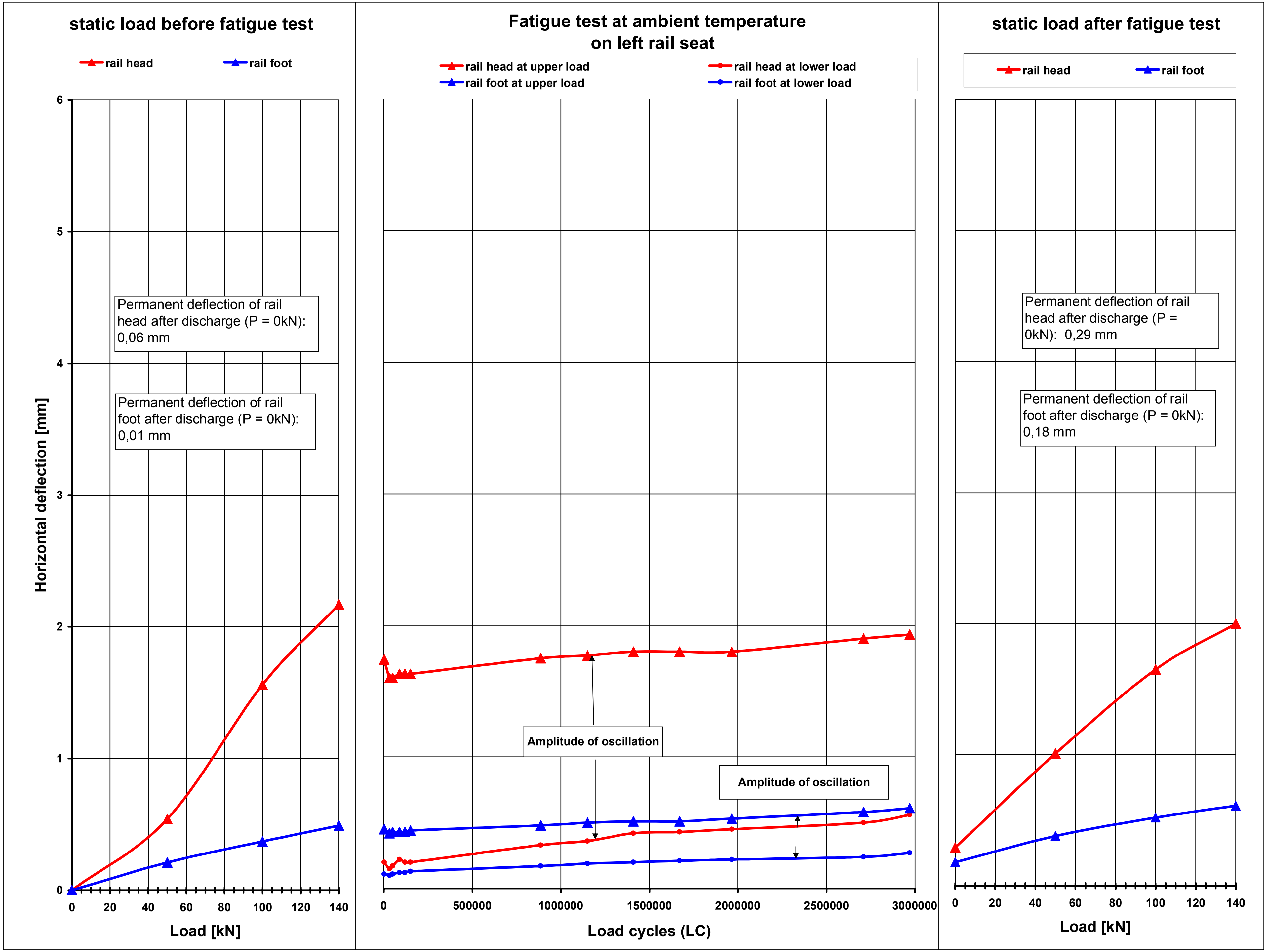
Vossloh Rail Fastening KS
with tension calmp Skl 12

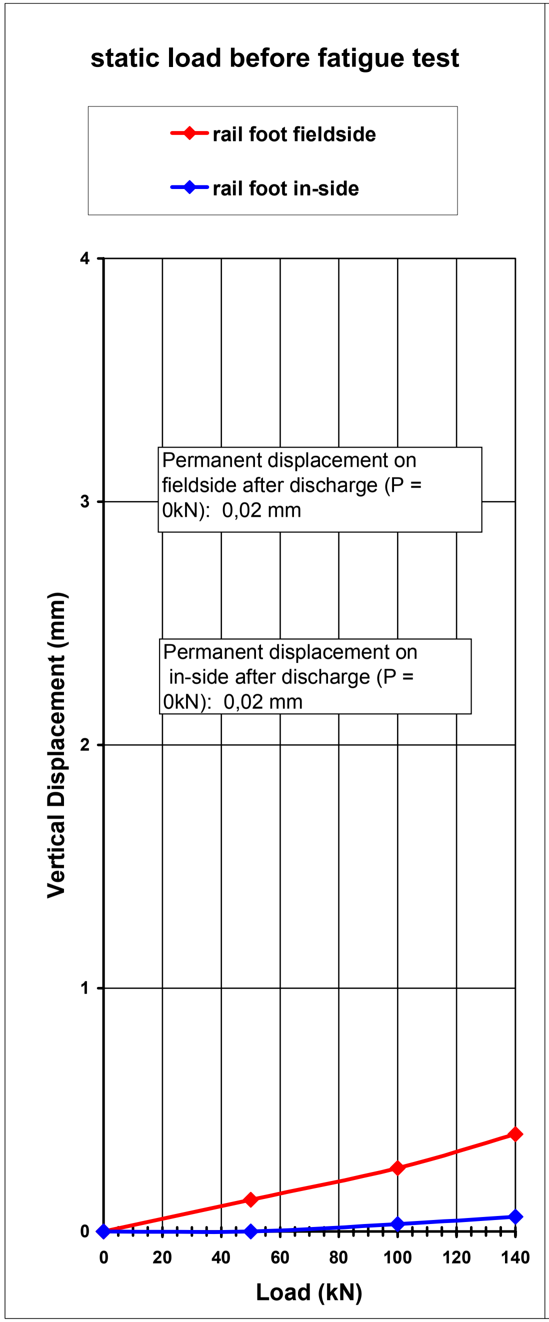
0.1202.d

Ersatz für: 1 8 558 1282
Ersetzt durch:

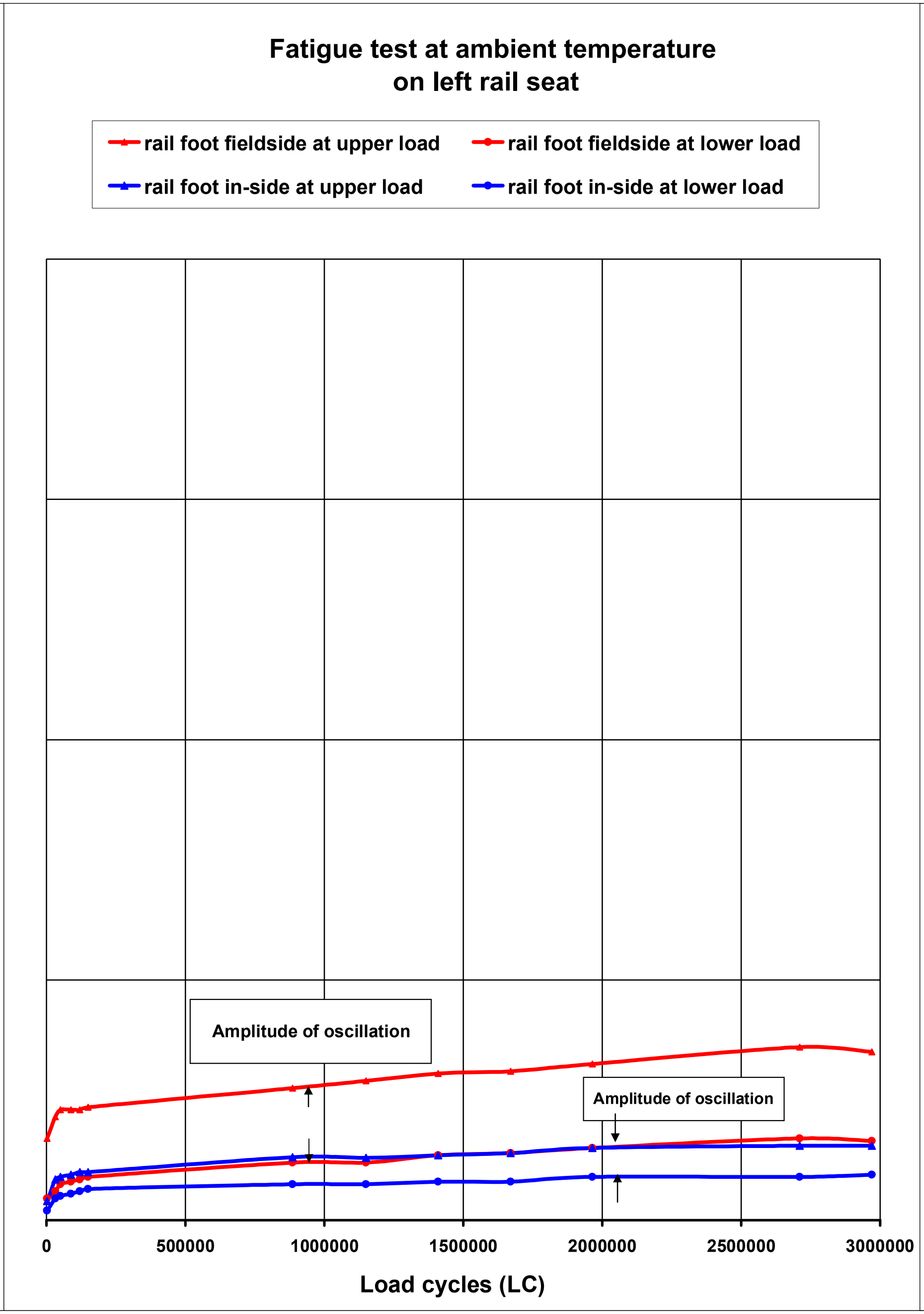
Konstruktive Änderungen bleiben im Interesse der Weiterentwicklung vorbehalten
In the interest of technical development design improvements will be reserved

Diese Zeichnung unterliegt nicht dem Änderungsdienst! This drawing is not subject to updating service!

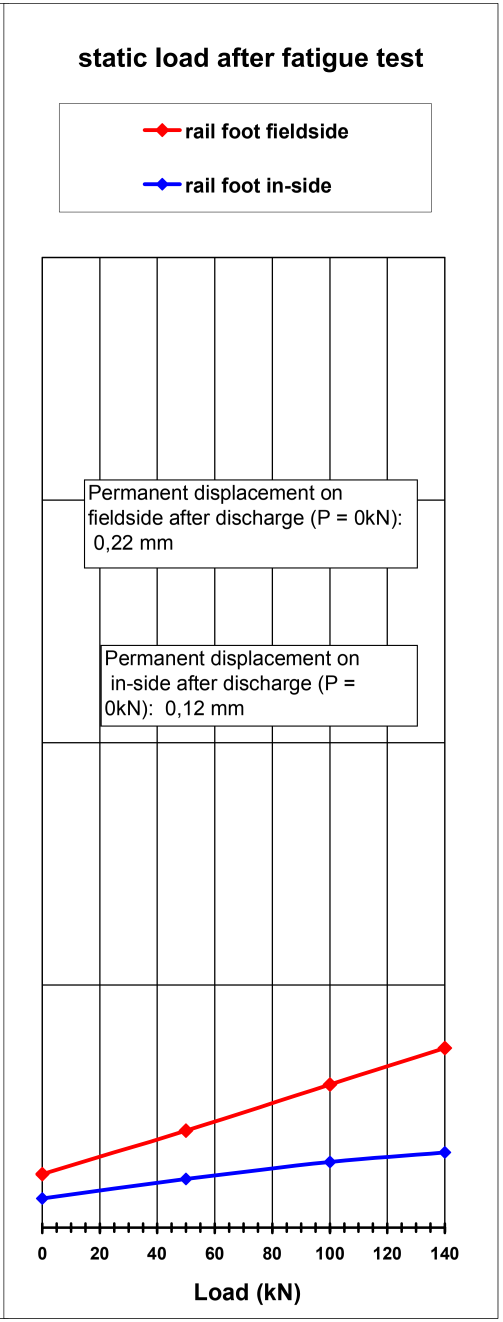

static load before fatigue test
rail head
rail foot
Permanent deflection of rail head after discharge (P = 0kN): 0,06 mm
Permanent deflection of rail foot after discharge (P = 0kN): 0,01 mm
Horizontal deflection [mm]
0
1
2
3
4
5
6
0
20
40
60
80
100
120
140
Load [kN]
Fatigue test at ambient temperature on left rail seat
rail head at upper load
rail head at lower load
rail foot at upper load
rail foot at lower load
Amplitude of oscillation
Amplitude of oscillation
0
500000
1000000
1500000
2000000
2500000
3000000
Load cycles (LC)
static load after fatigue test
rail head
rail foot
Permanent deflection of rail head after discharge (P = 0kN): 0,29 mm
Permanent deflection of rail foot after discharge (P = 0kN): 0,18 mm
0
20
40
60
80
100
120
140
Load [kN]



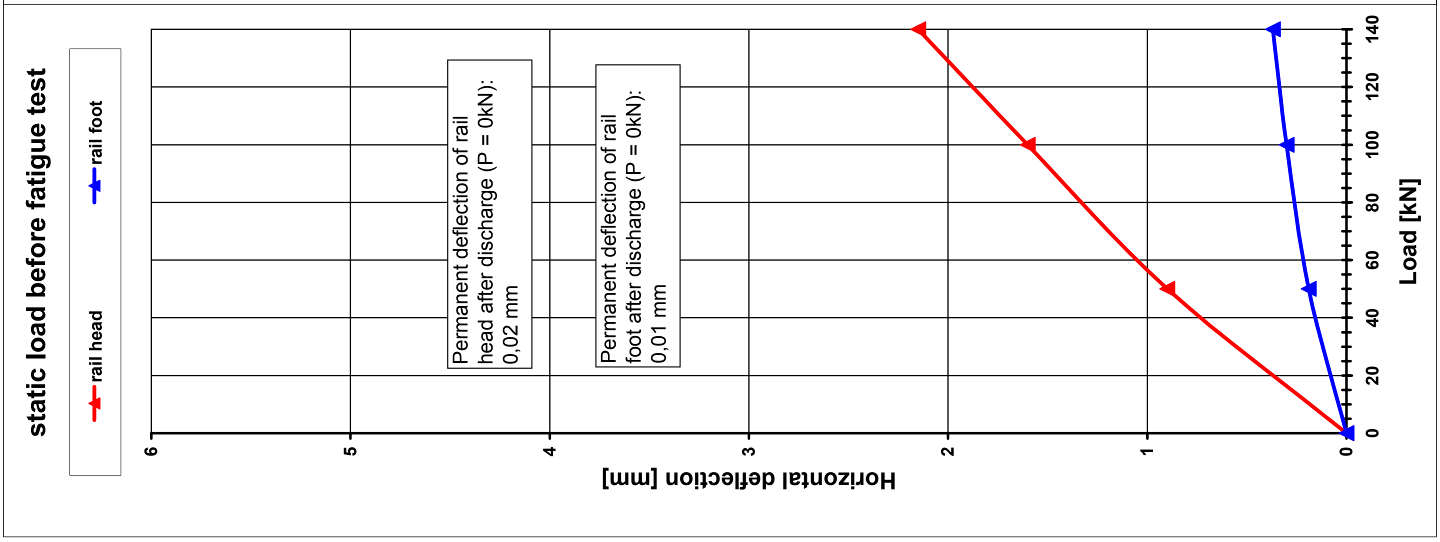
static load before fatigue test



Fatigue test at ambient temperature on left rail seat

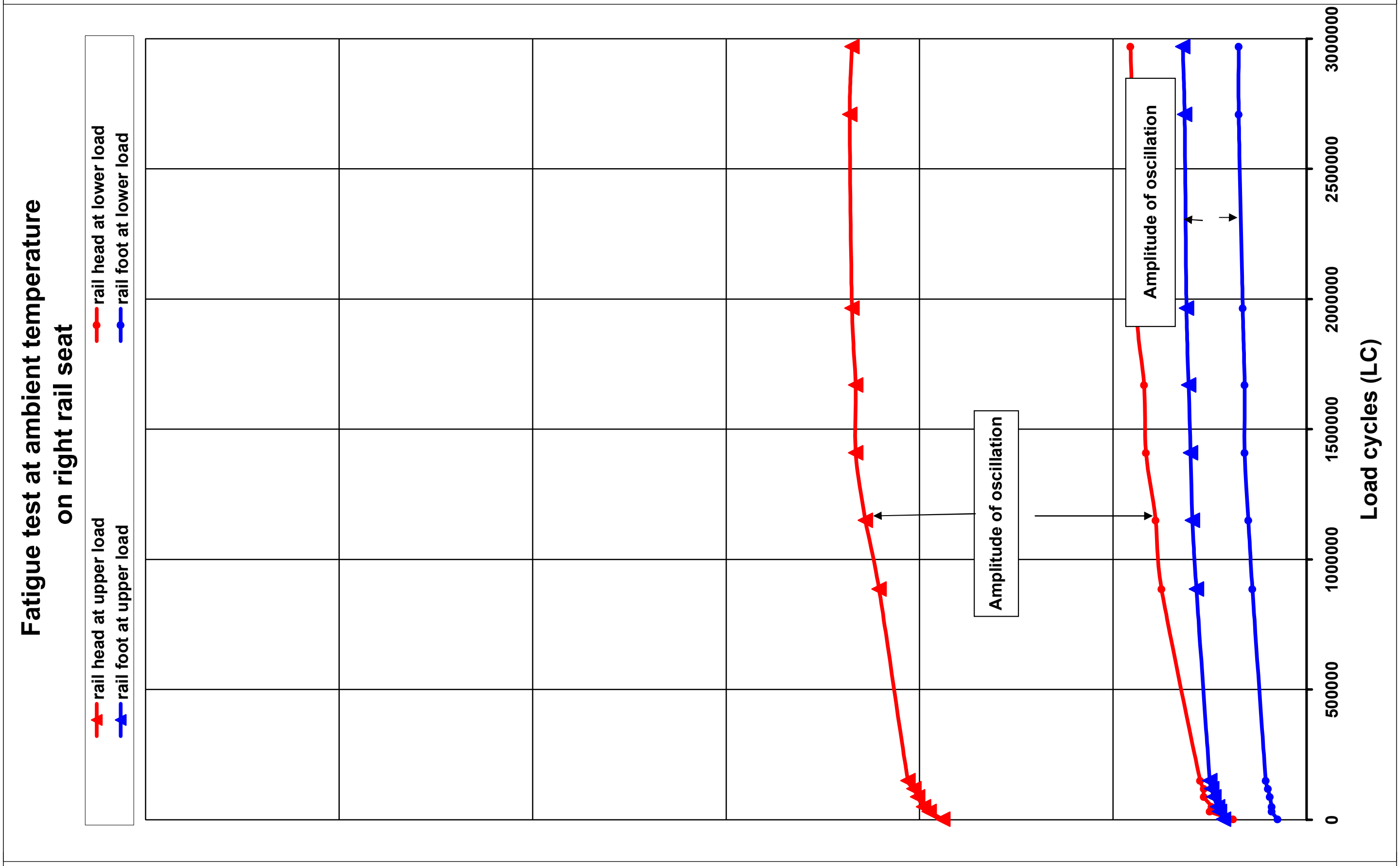


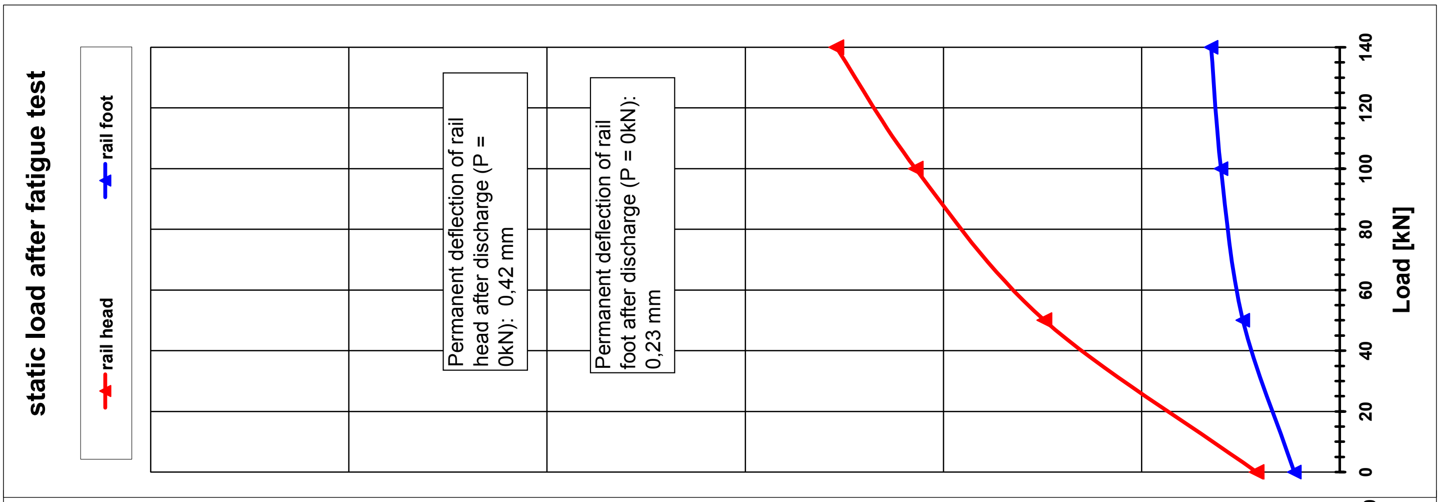
static load after fatigue test



Permanent deflection of rail head after discharge (P = 0kN): 0,02 mm

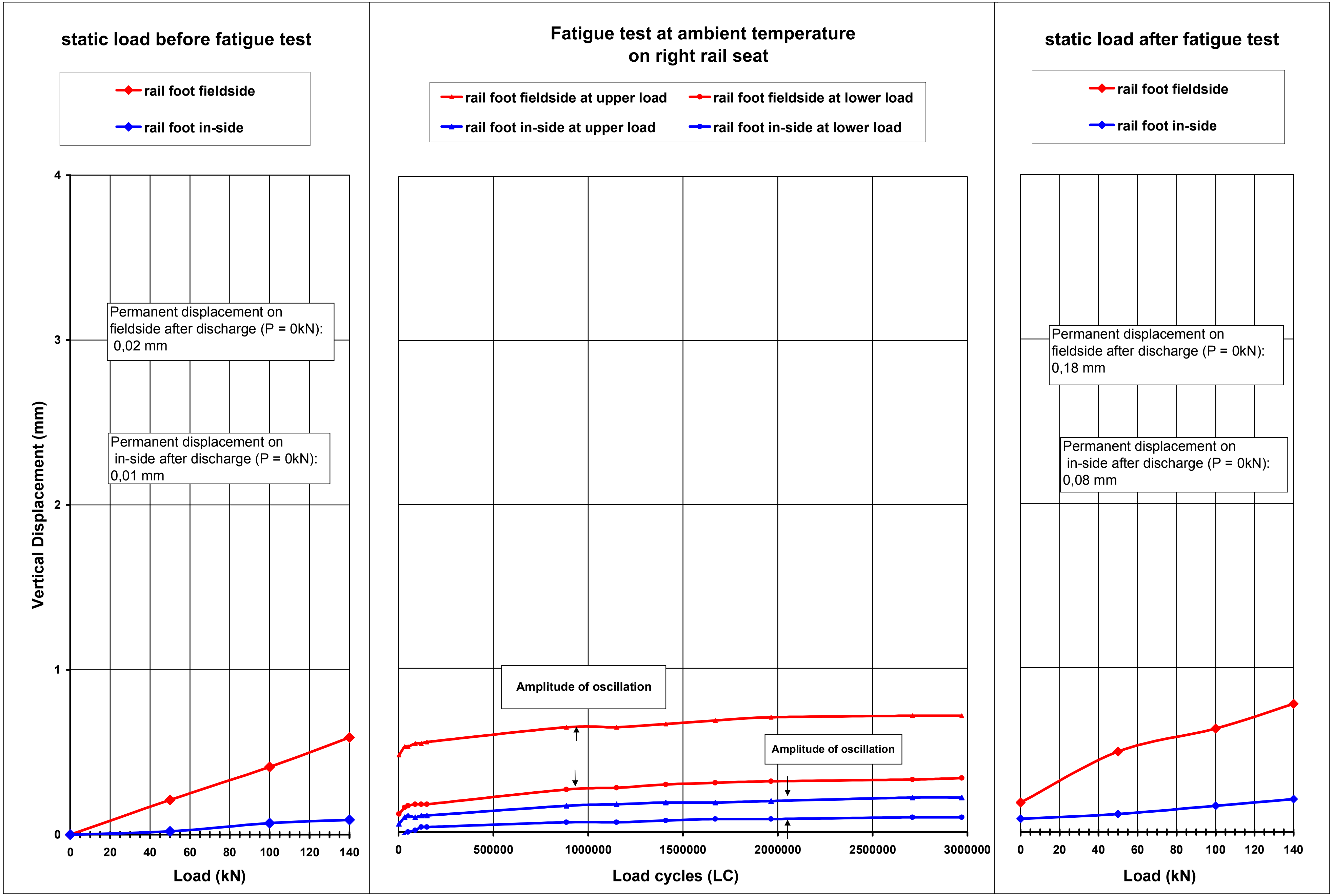
Permanent deflection of rail foot after discharge (P = 0kN): 0,01 mm



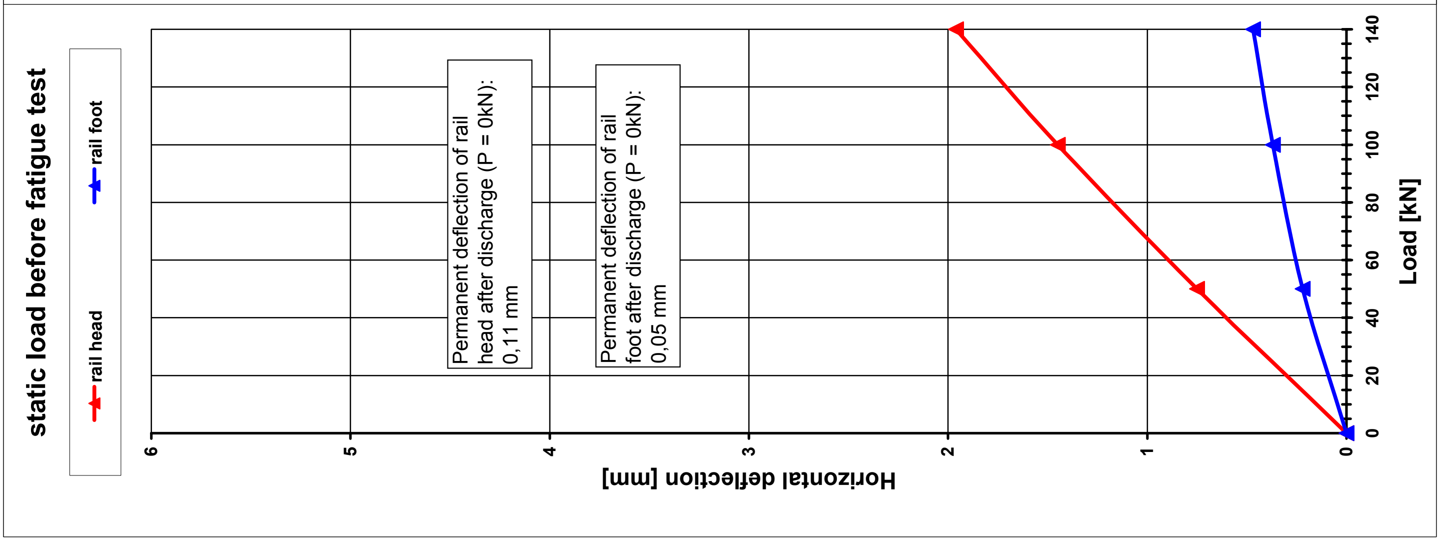


Permanent deflection of rail head after discharge (P = 0kN): 0,42 mm

Permanent deflection of rail foot after discharge (P = 0kN): 0,23 mm


static load before fatigue test
rail foot fieldside
rail foot in-side
Vertical Displacement (mm)
0
1
2
3
4
Permanent displacement on fieldside after discharge (P = 0kN): 0,02 mm
Permanent displacement on in-side after discharge (P = 0kN): 0,01 mm
0
20
40
60
80
100
120
140
Load (kN)
Fatigue test at ambient temperature on right rail seat
rail foot fieldside at upper load
rail foot fieldside at lower load
rail foot in-side at upper load
rail foot in-side at lower load
Amplitude of oscillation
Amplitude of oscillation
0
500000
1000000
1500000
2000000
2500000
3000000
Load cycles (LC)
static load after fatigue test
rail foot fieldside
rail foot in-side
Permanent displacement on fieldside after discharge (P = 0kN): 0,18 mm
Permanent displacement on in-side after discharge (P = 0kN): 0,08 mm
0
20
40
60
80
100
120
140
Load (kN)

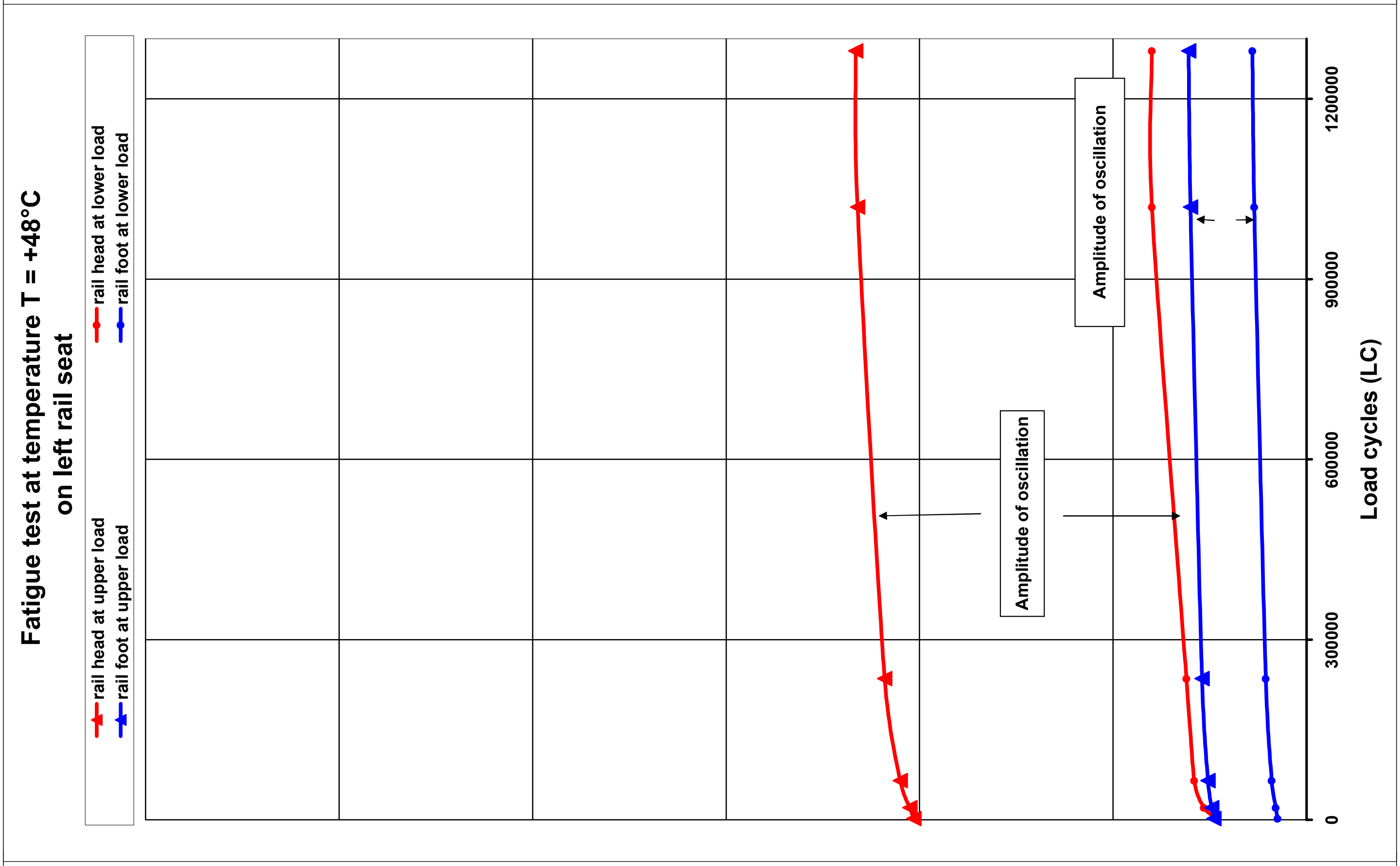
static load before fatigue test



Permanent deflection of rail head after discharge (P = 0kN): 0,11 mm

Permanent deflection of rail foot after discharge (P = 0kN): 0,05 mm

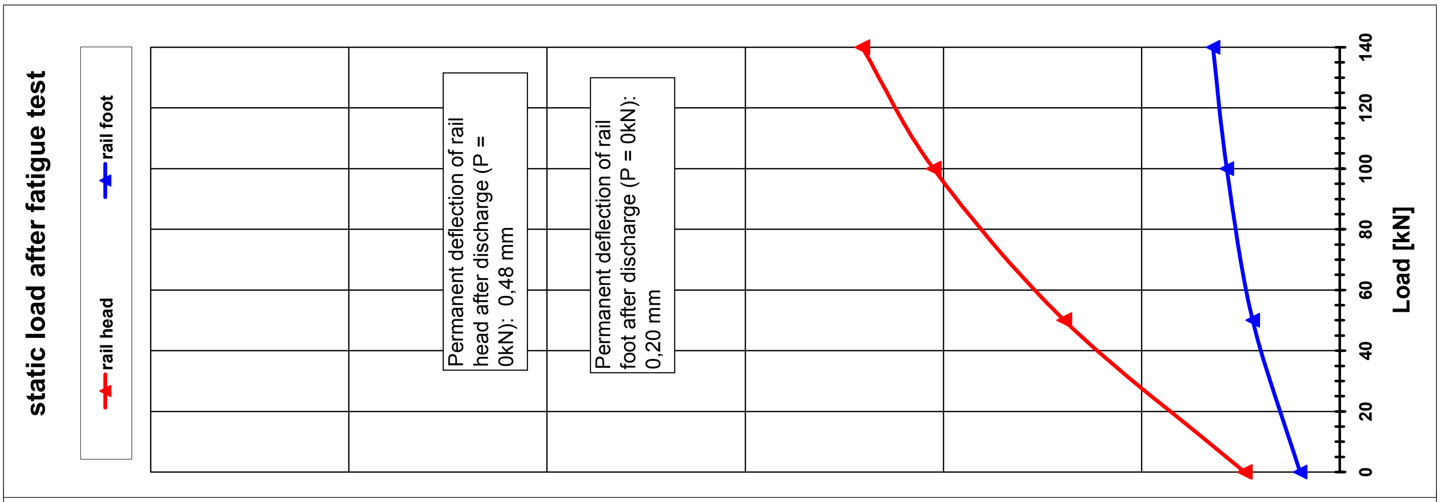
Fatigue test at temperature T = +48°C on left rail seat



Amplitude of oscillation

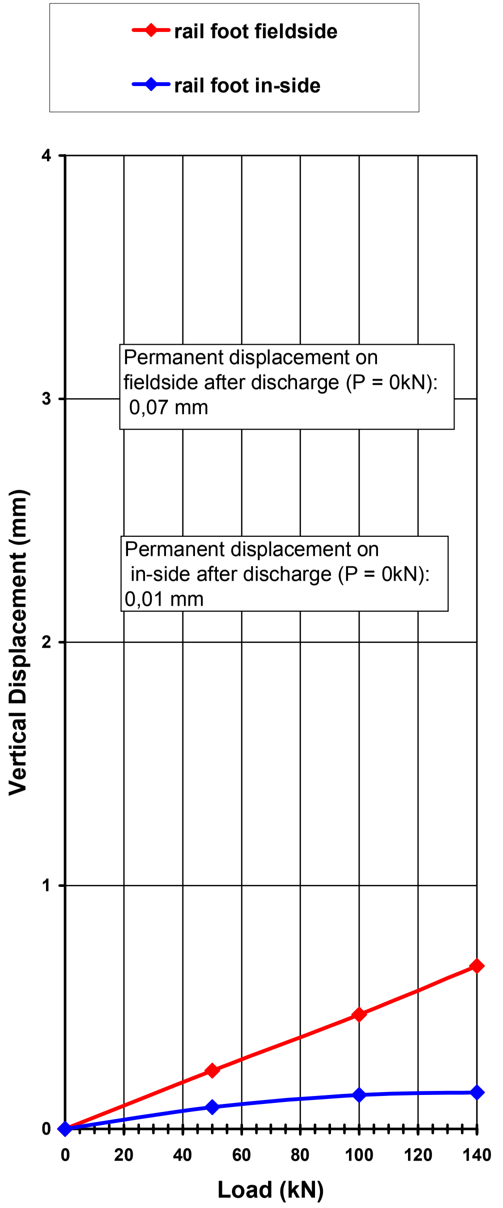
Amplitude of oscillation

static load after fatigue test

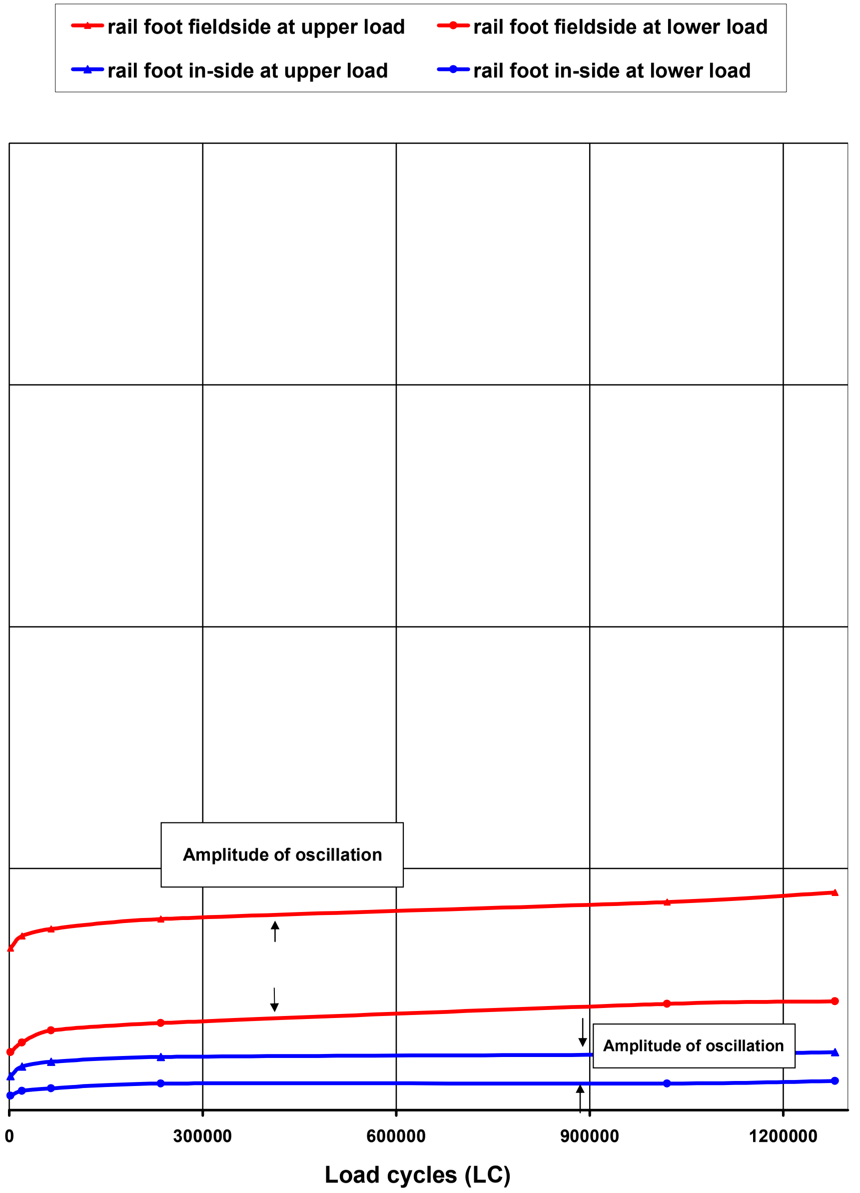


Permanent deflection of rail head after discharge (P = 0kN): 0,48 mm

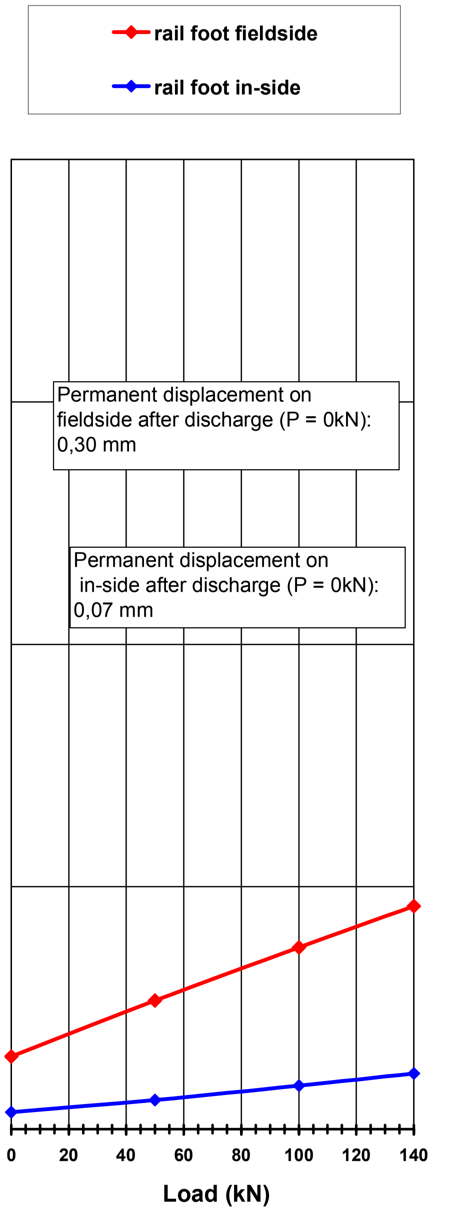
Permanent deflection of rail foot after discharge (P = 0kN): 0,20 mm static load before fatigue test

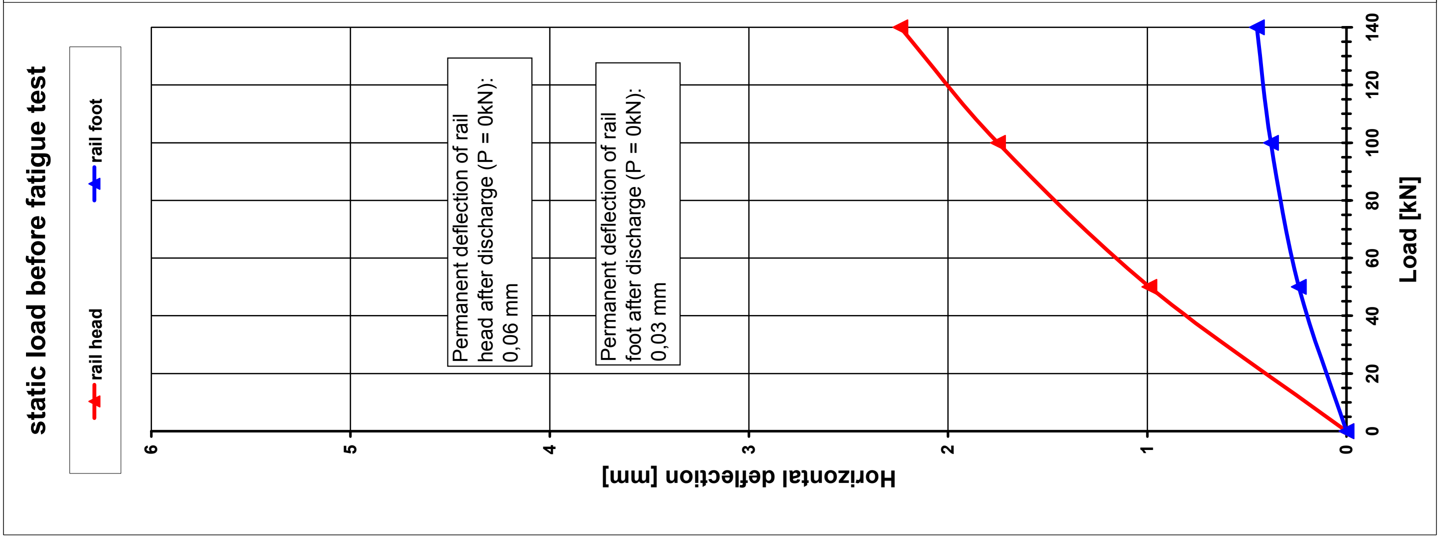


Fatigue test at temperature T = +48°C on left rail seat

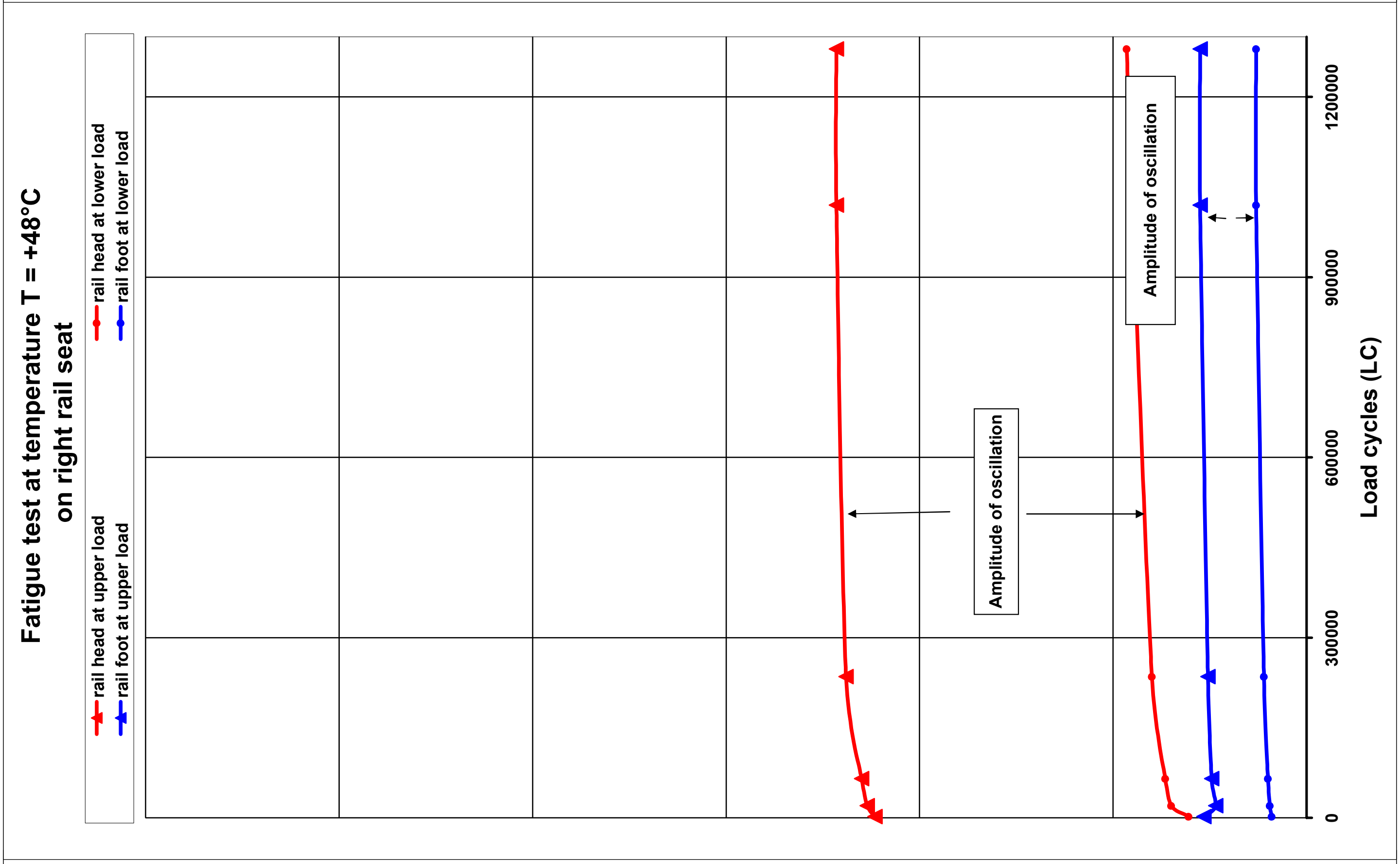


static load after fatigue test

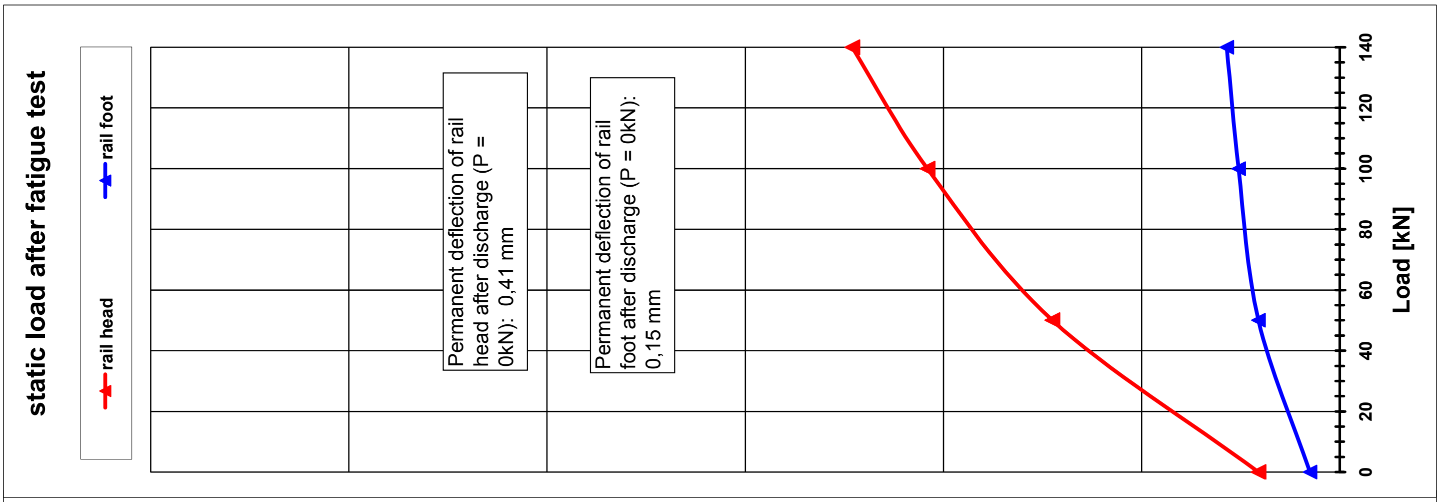




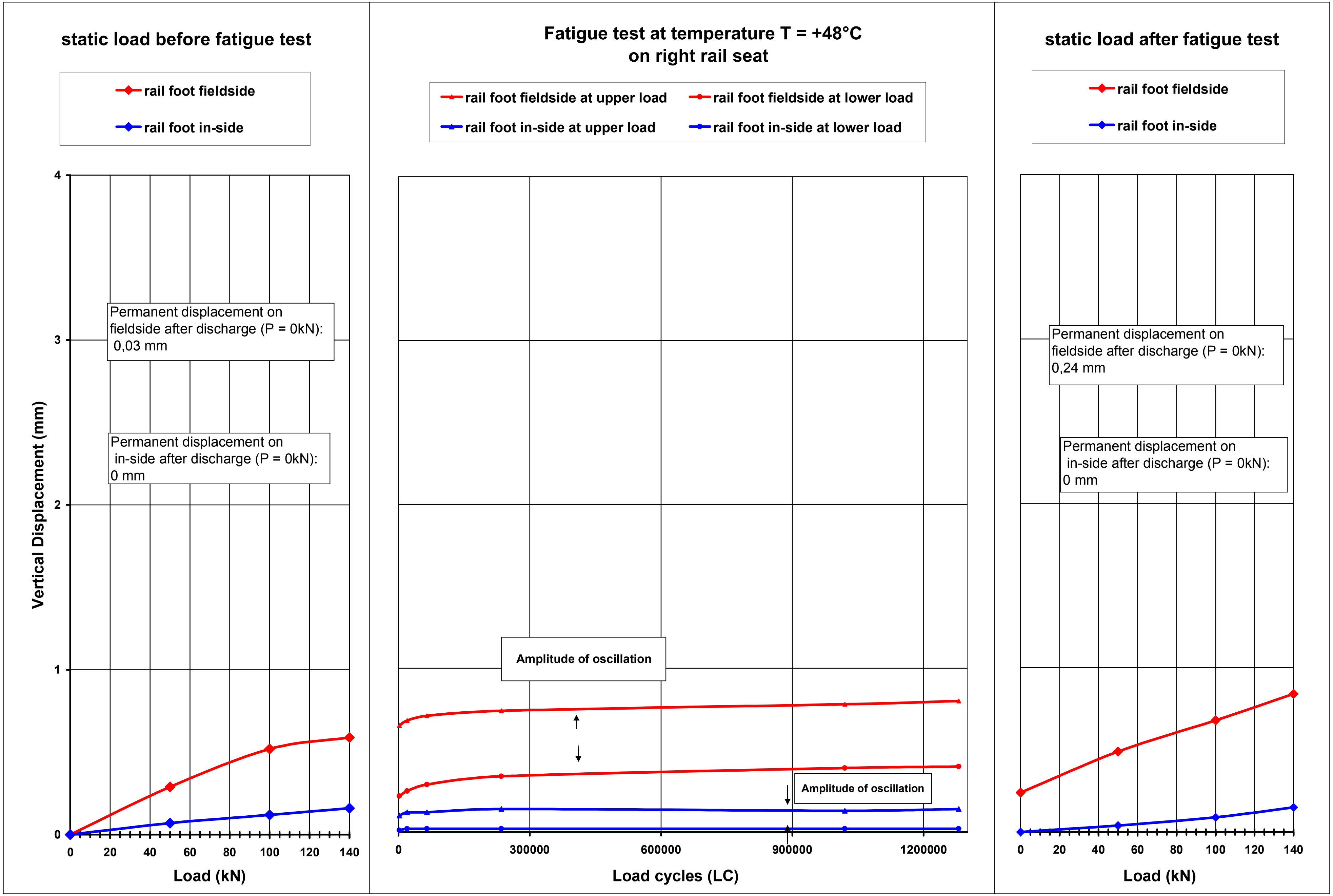
static load before fatigue test



Fatigue test at temperature T = +48°C on right rail seat



static load after fatigue test



static load before fatigue test

Permanent displacement on fieldside after discharge (P = 0kN): 0,03 mm

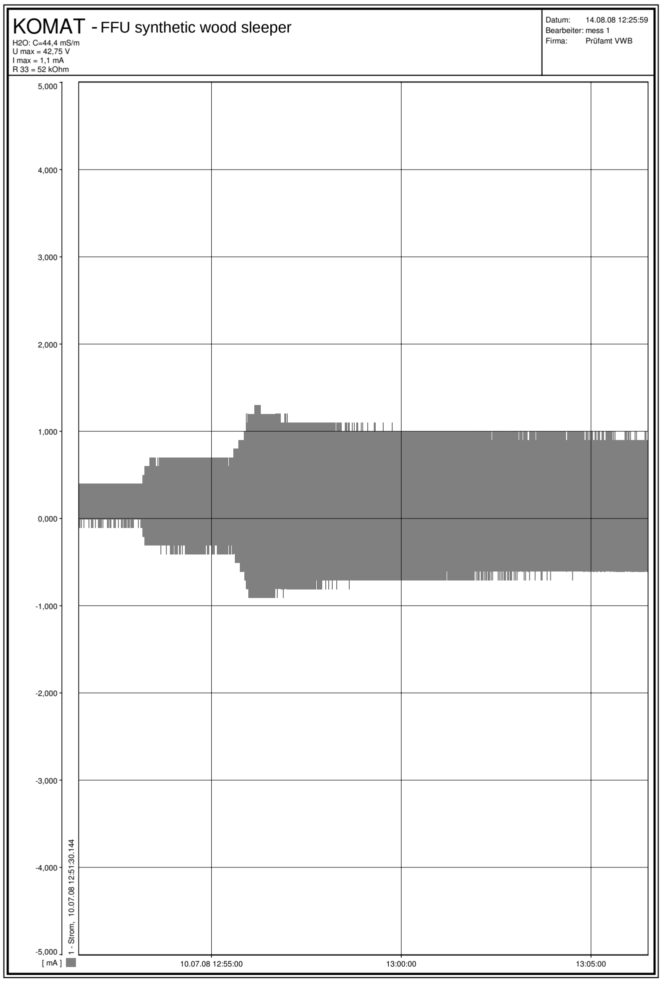
Permanent displacement on in-side after discharge (P = 0kN): 0 mm

Fatigue test at temperature T = +48°C on right rail seat

static load after fatigue test

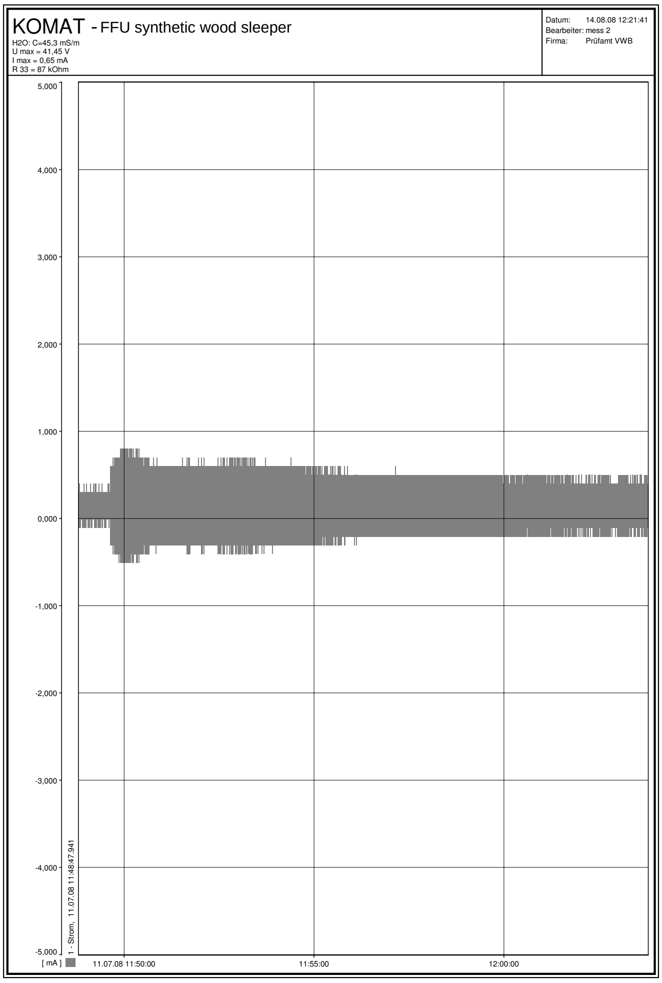
Permanent displacement on fieldside after discharge (P = 0kN): 0,24 mm

Permanent displacement on in-side after discharge (P = 0kN): 0 mm



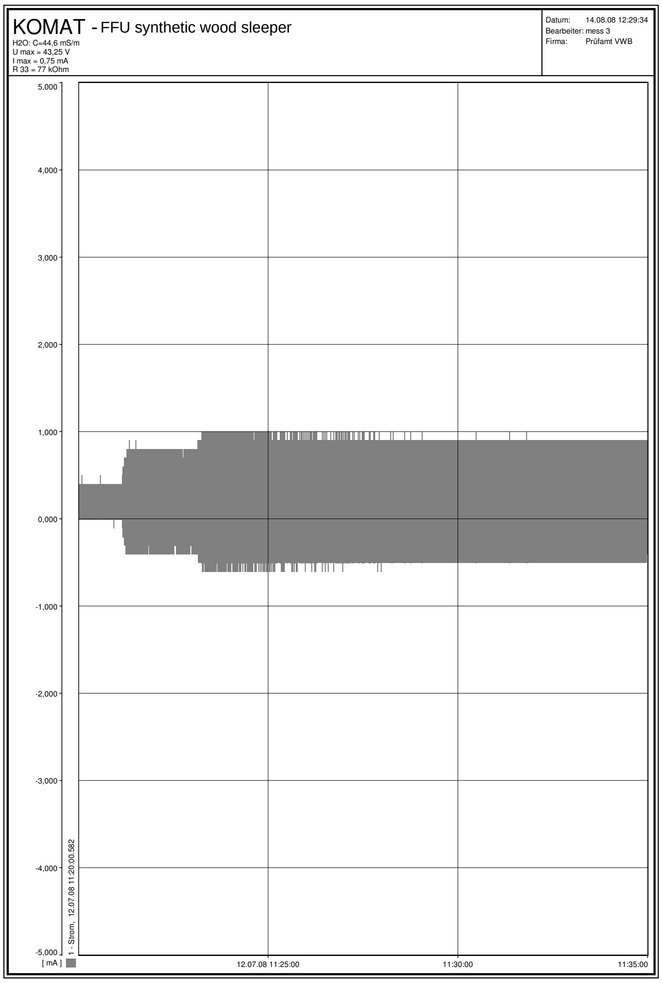
KOMAT - FFU synthetic wood sleeper
H2O: C=44,4 mS/m
U max = 42,75 V
I max = 1,1 mA
R 33 = 52 kOhm

Datum: 14.08.08 12:25:59
Bearbeiter: mess 1
Firma: Prüfamt VWB



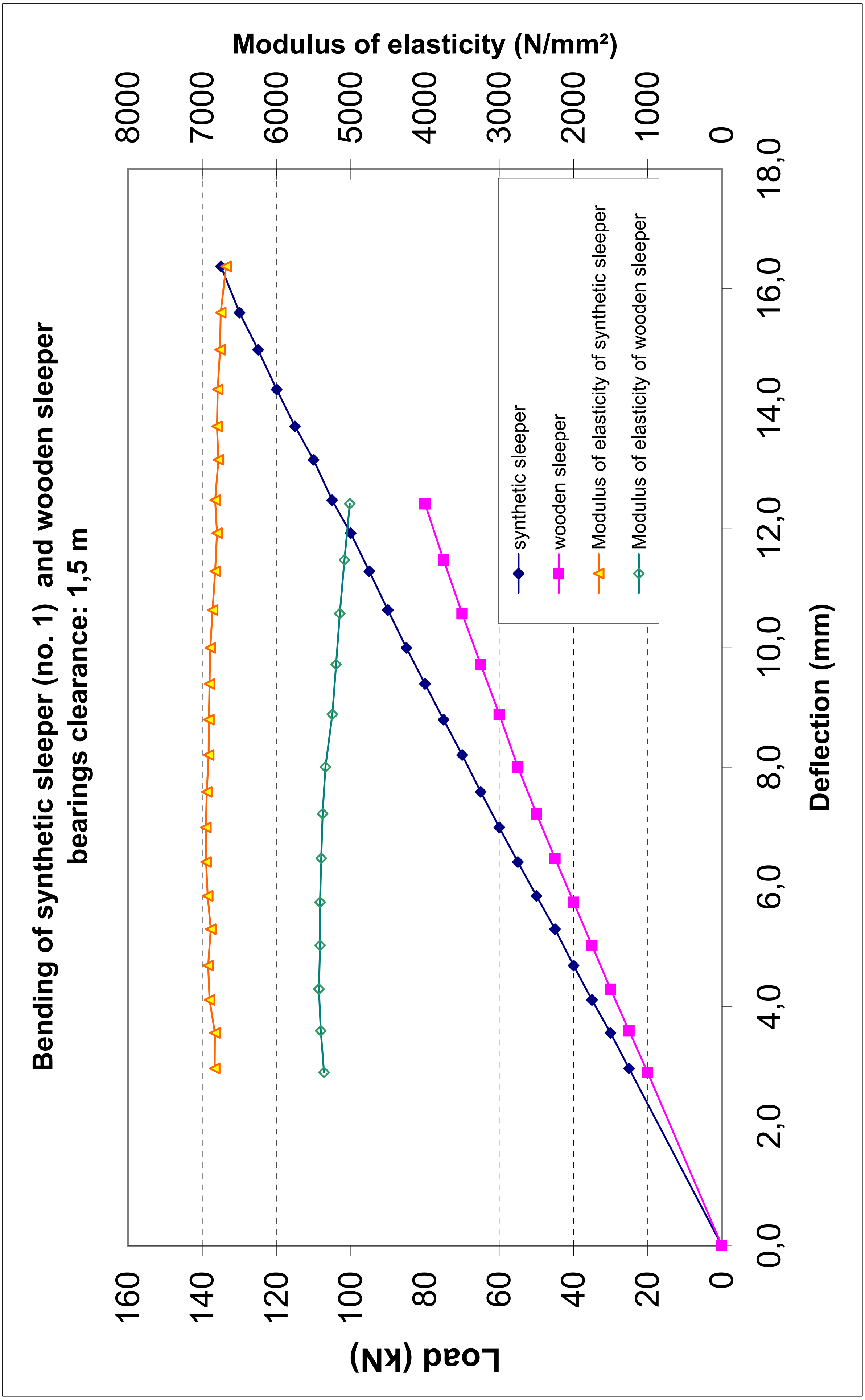
KOMAT - FFU synthetic wood sleeper
H2O: C=45,3 mS/m
U max = 41,45 V
I max = 0,65 mA
R 33 = 87 kOhm

Datum: 14.08.08 12:21:41
Bearbeiter: mess 2
Firma: Prüfamt VWB

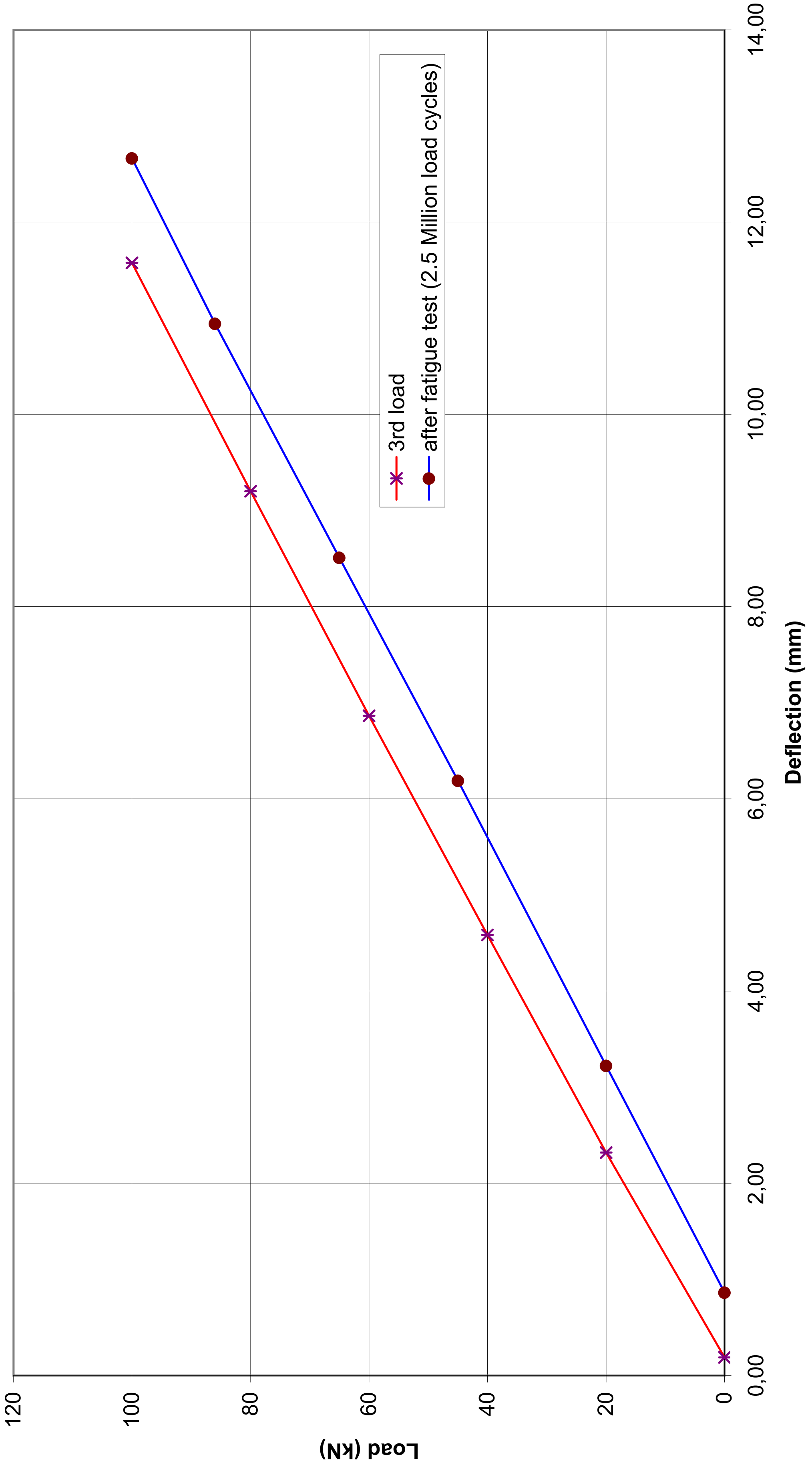


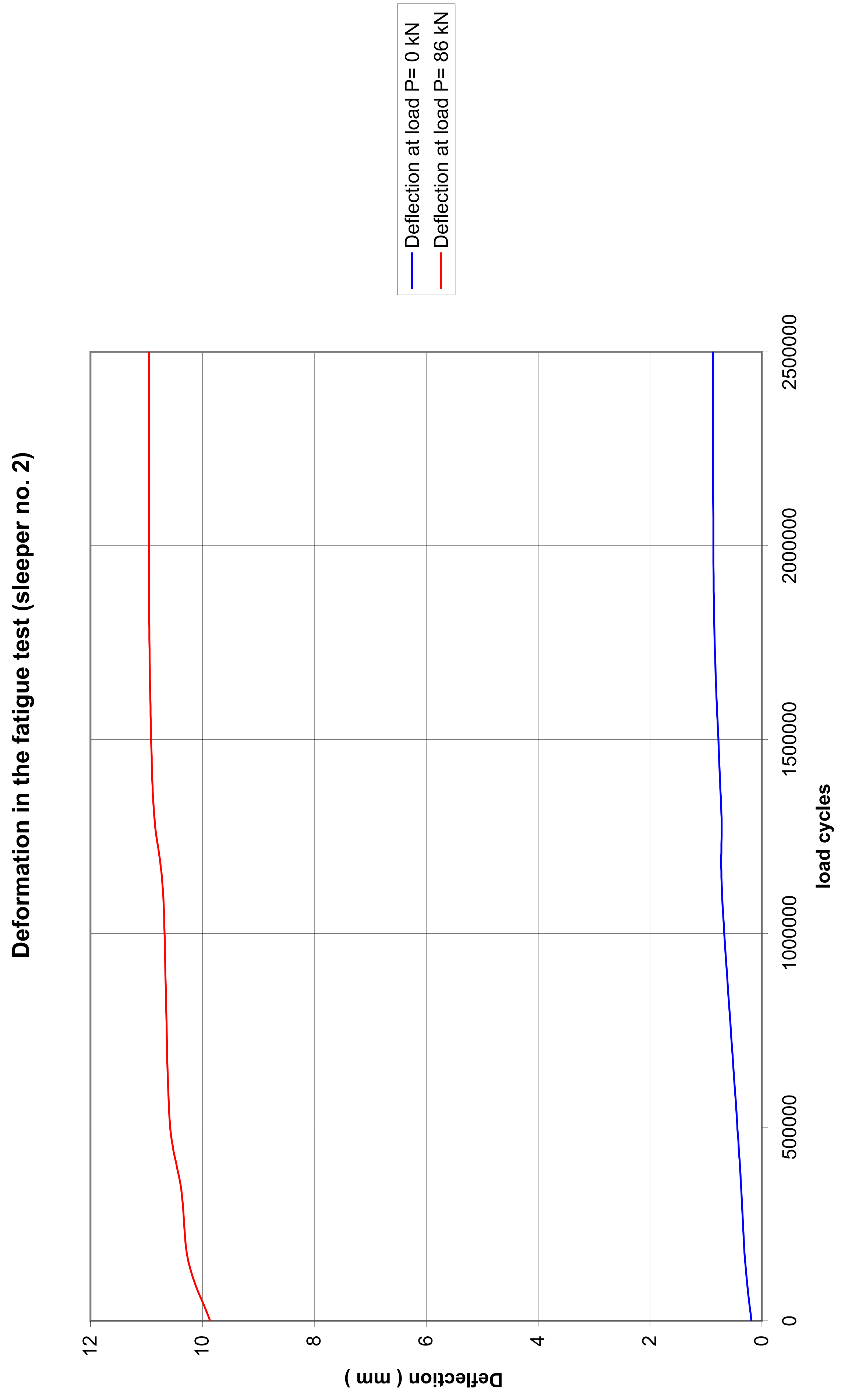
KOMAT - FFU synthetic wood sleeper
H2O: C=44,6 mS/m
U max = 43,25 V
I max = 0,75 mA
R 33 = 77 kOhm

Datum: 14.08.08 12:29:34
Bearbeiter: mess 3
Firma: Prüfamt VWB


Bending of synthetic sleeper (no. 1) and wooden sleeper
bearings clearance: 1,5 m
Modulus of elasticity (N/mm²)
8000
7000
6000
5000
4000
3000
2000
1000
0
Load (kN)
160
140
120
100
80
60
40
20
0
Deflection (mm)
0,0
2,0
4,0
6,0
8,0
10,0
12,0
14,0
16,0
18,0
synthetic sleeper
wooden sleeper
Modulus of elasticity of synthetic sleeper
Modulus of elasticity of wooden sleeper

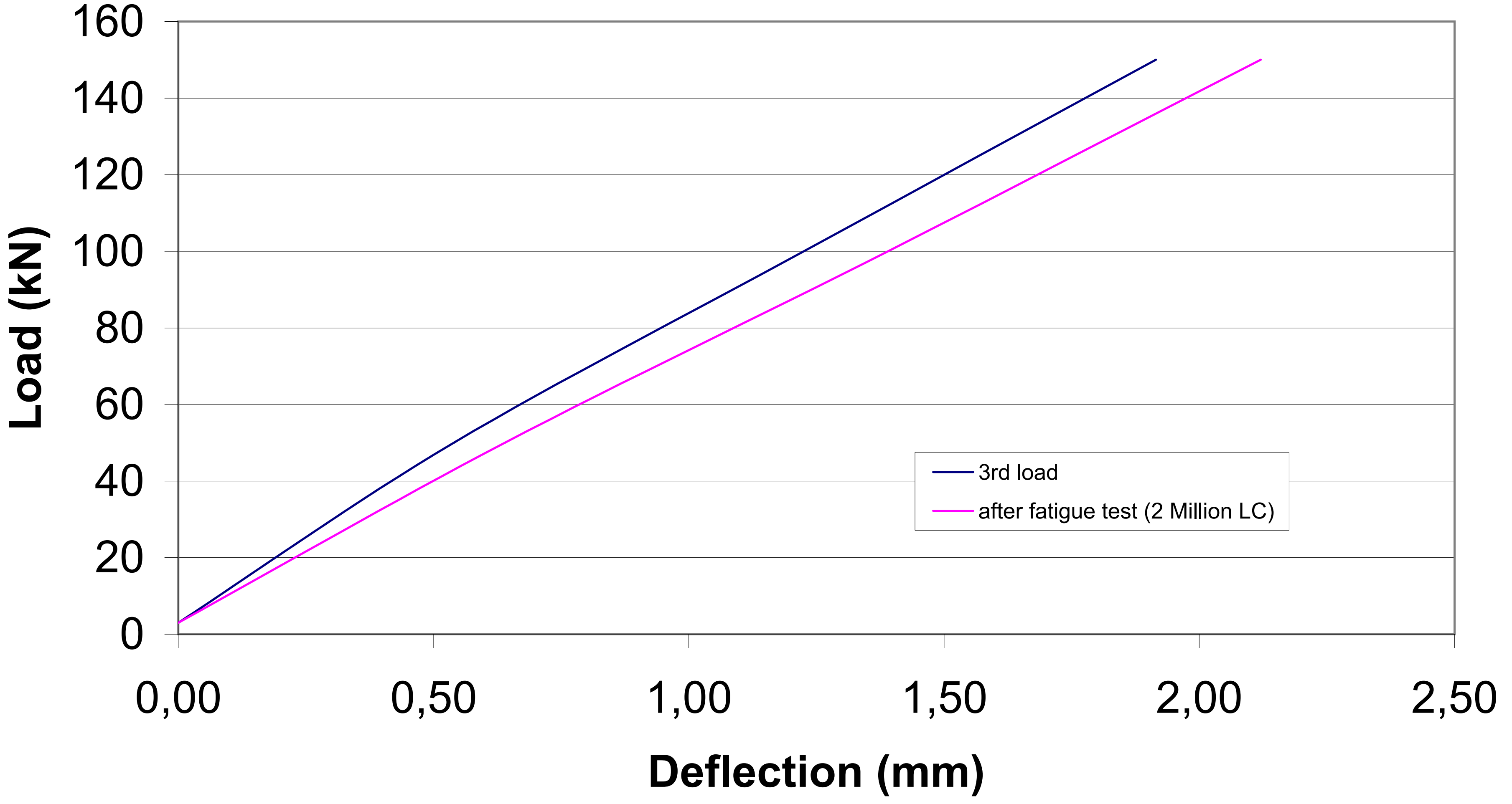
Deflection of the synthetic sleeper (fatigue test on sleeper no. 2)



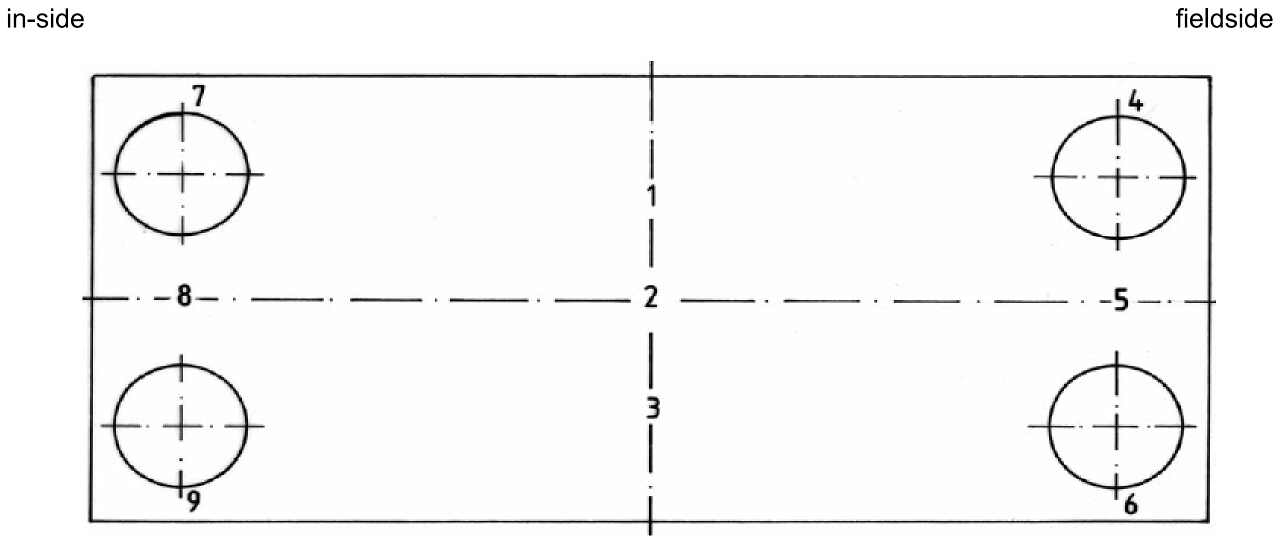


Deformation in the fatigue test (sleeper no. 2)

Bending of synthetic sleeper no. 4
(bearings clearance: 0,6 m)

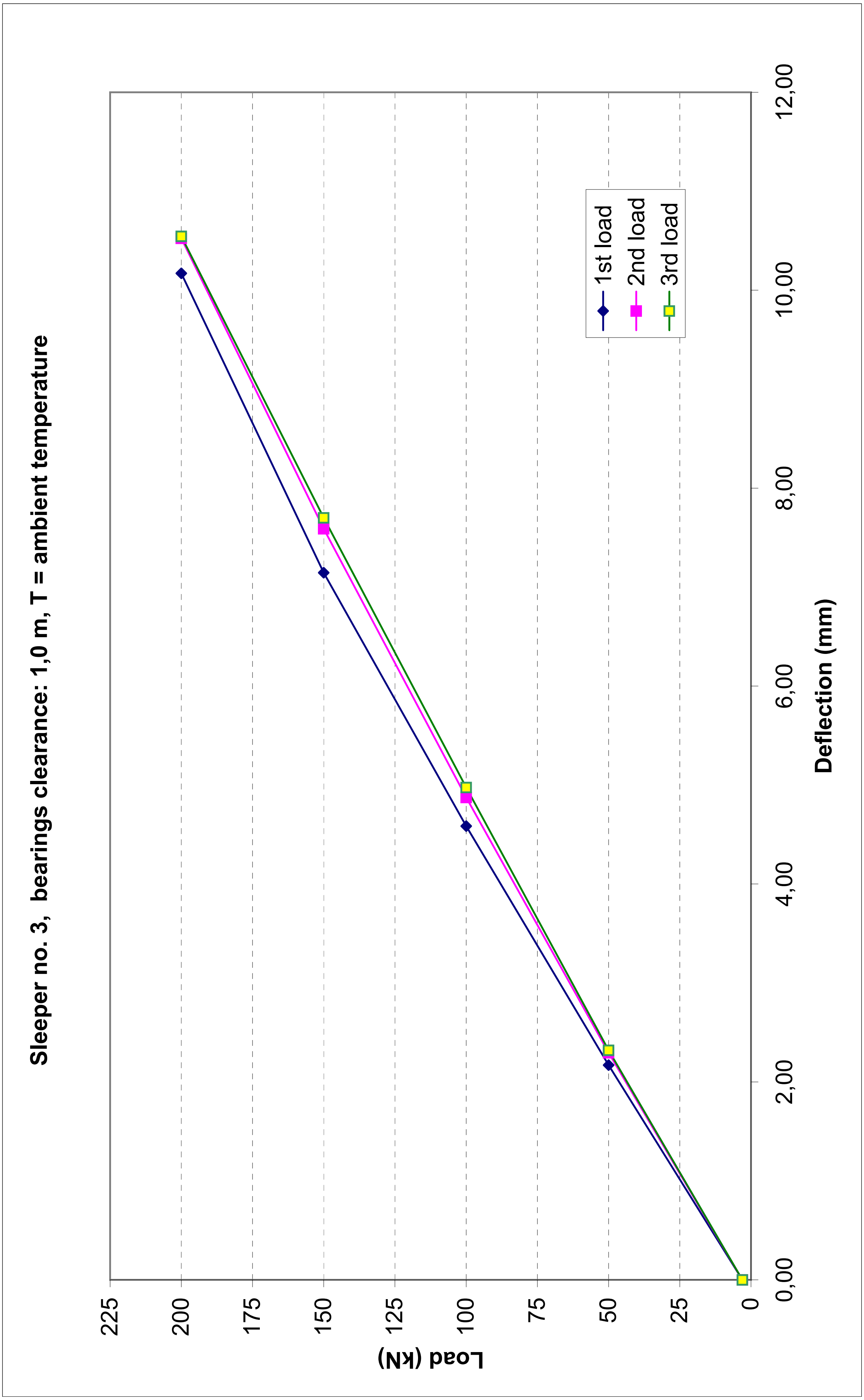


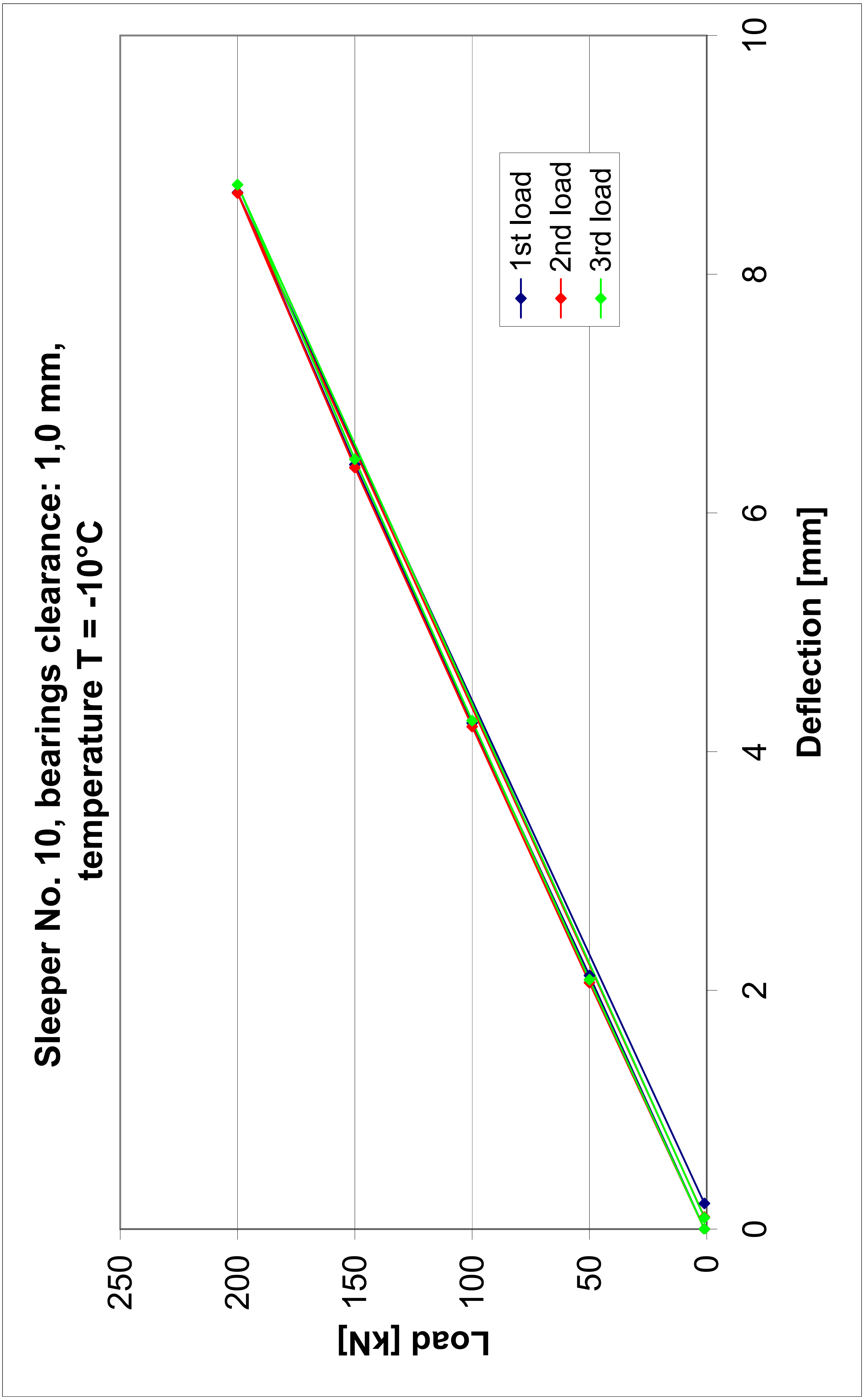
Compression test



Permanent deformation [mm]

measuring point load [kN]	1	2	3	4	5	6	7	8	9
100	-	-	-	-	-	-	-	-	-
125	-	-	-	-	-	-	-	-	-
150	-	-	-	-	-	-	-	-	-
175	0,05	0,05	-	-	0,05	0,05	-	0,05	-
200	0,05	0,10	0,05	-	0,10	0,05	-	0,10	-
225	0,05	0,15	0,15	-	0,15	0,10	-	0,10	-
250	0,15	0,40	0,30	-	0,15	0,10	-	0,15	0,05
275	0,60	0,60	0,50	0,05	0,15	0,10	0,05	0,15	0,05
300	0,80	0,80	0,70	0,05	0,15	0,10	0,10	0,15	0,10

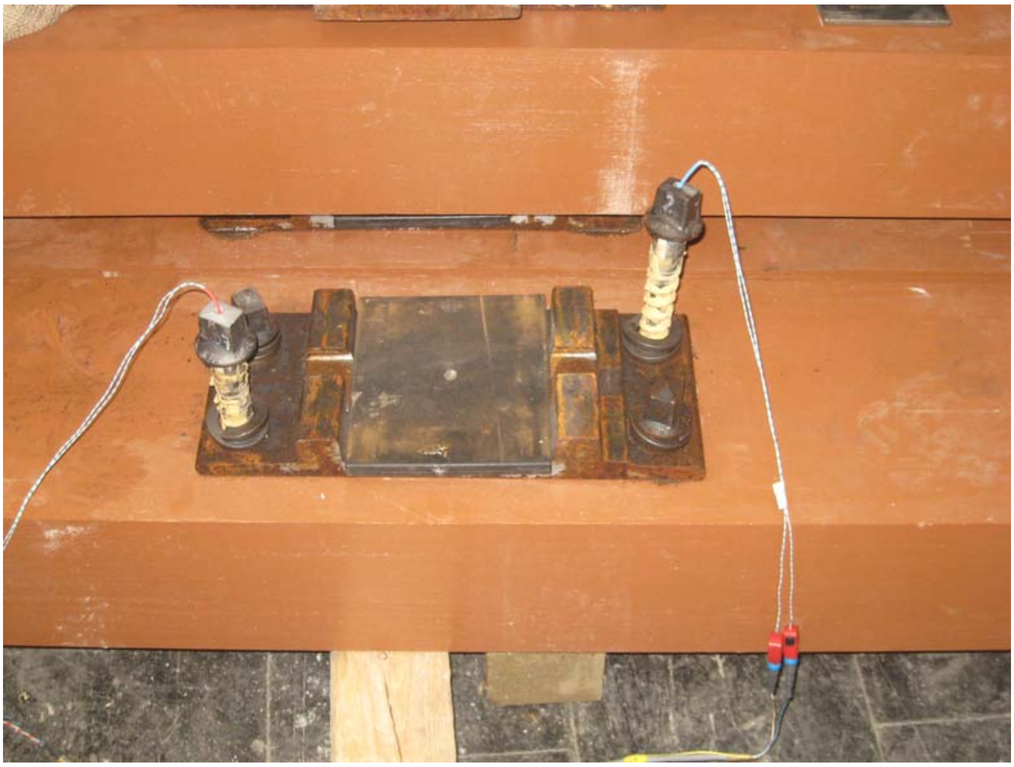

Sleeper no. 3, bearings clearance: 1,0 m, T = ambient temperature
Load (kN)
225
200
175
150
125
100
75
50
25
0
Deflection (mm)
0,00
2,00
4,00
6,00
8,00
10,00
12,00
1st load
2nd load
3rd load



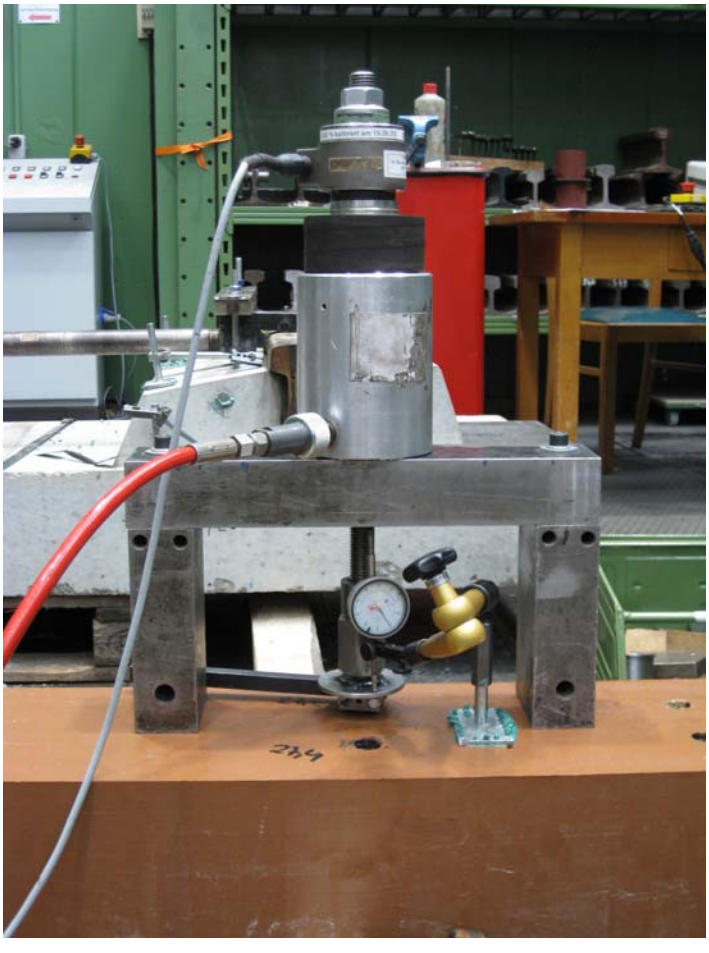
Sleeper No. 10, bearings clearance: 1,0 mm, temperature T = -10°C

Repeated load test (fatigue test) in accordance with DIN EN 13230-3

Permanent deformation of 0.3 to 0.7 mm on the sleeper surface after fatigue test (3.0 Million + 1.28 Million load cycles).



Determination of tensile force in the sleeper screw, depending on torque moment and time.



Pull-out test

The tup with a wheel-flange shaped blade penetrates into the sleeper edge in a proper way. The damage is limited to a small area near impact position.

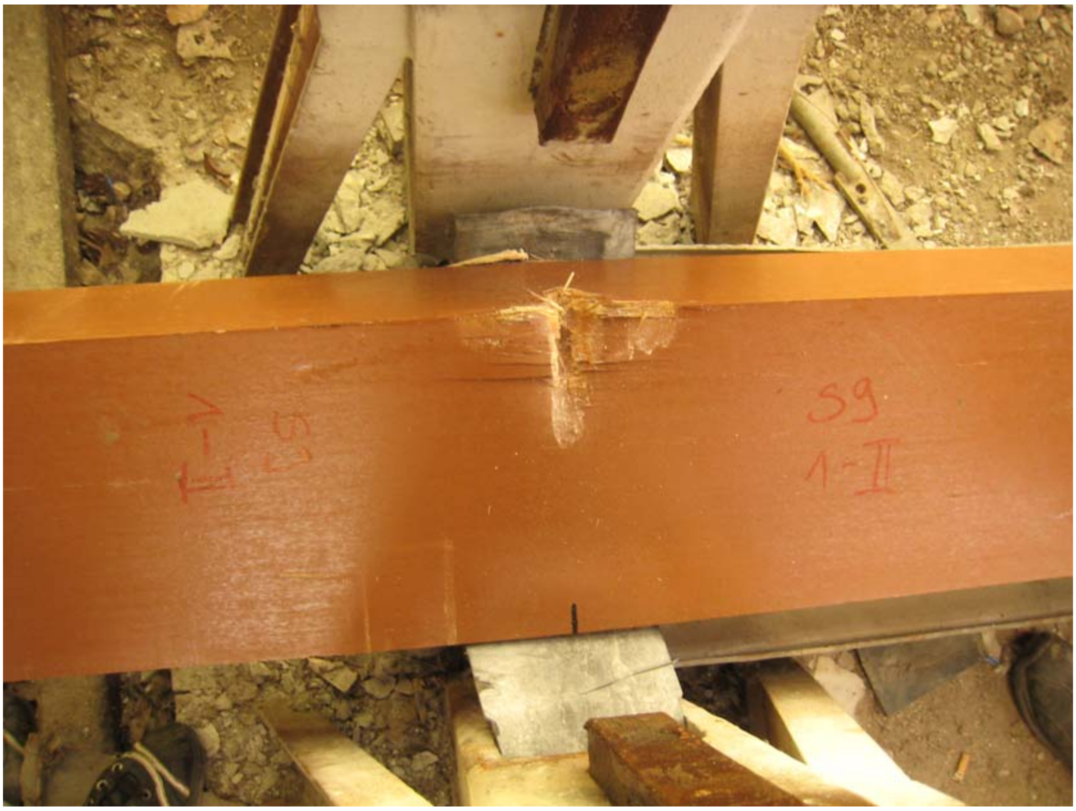
Cutted fibres after the second impact in derailment test I.

By derailment test II (impact on fieldside of the rail, 15 cm distance from sleeper front end) a wedge-shaped cutout is removed from the sleeper.

Wedge-shaped cutout after second impact in derailment test II.

View of sleeper S8 after the second impact in derailment test I.

Wedge-shaped cutout of sleeper S8 derailment test II.



Notch in sleeper S9 after derailment test I.

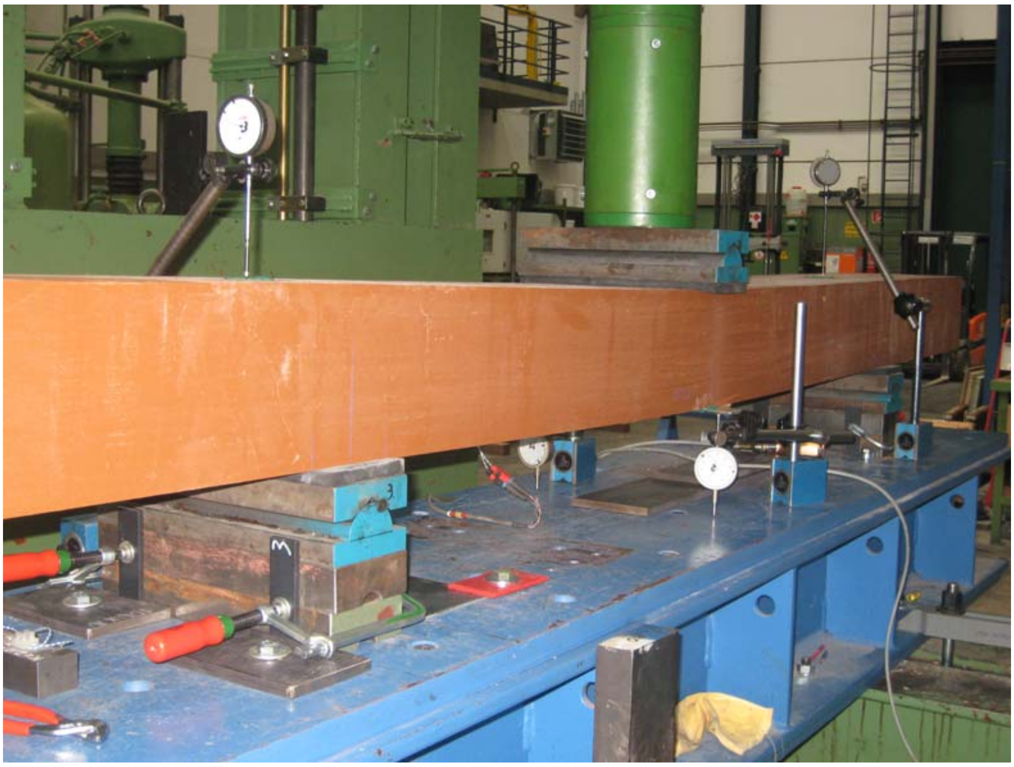
Caused by the homogeneous structure of the synthetic sleeper the derailment test shows clear and reproducible results.

The synthetic sleepers do not show any warping after the derailment test.

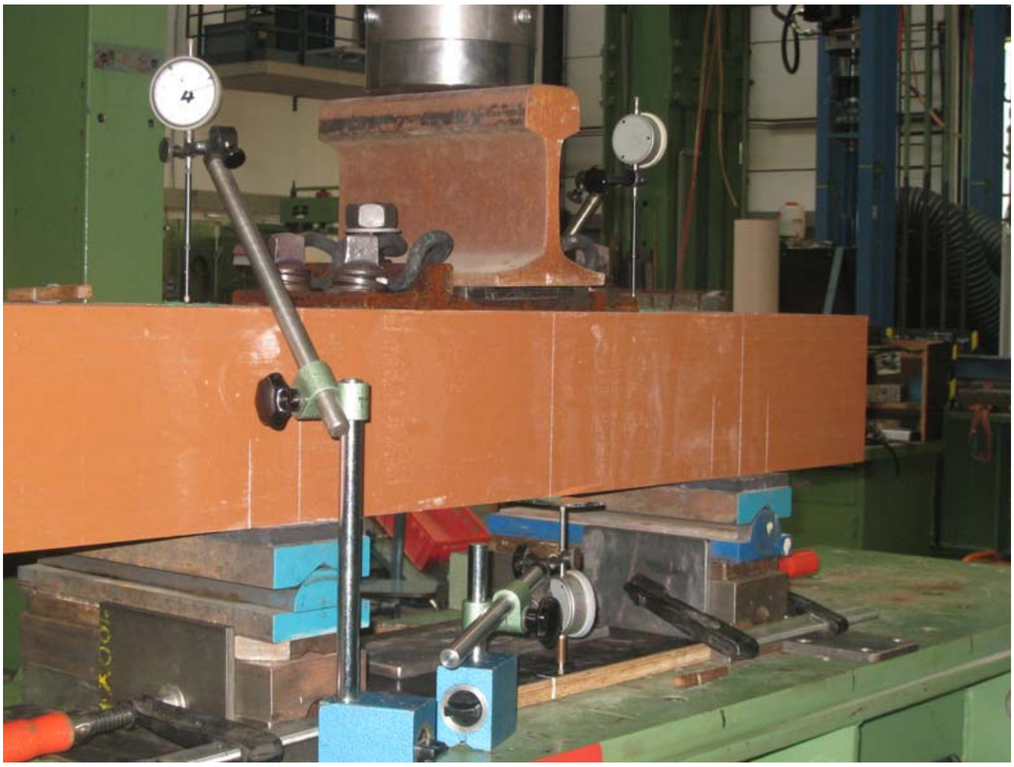
Synthetic wood sleeper

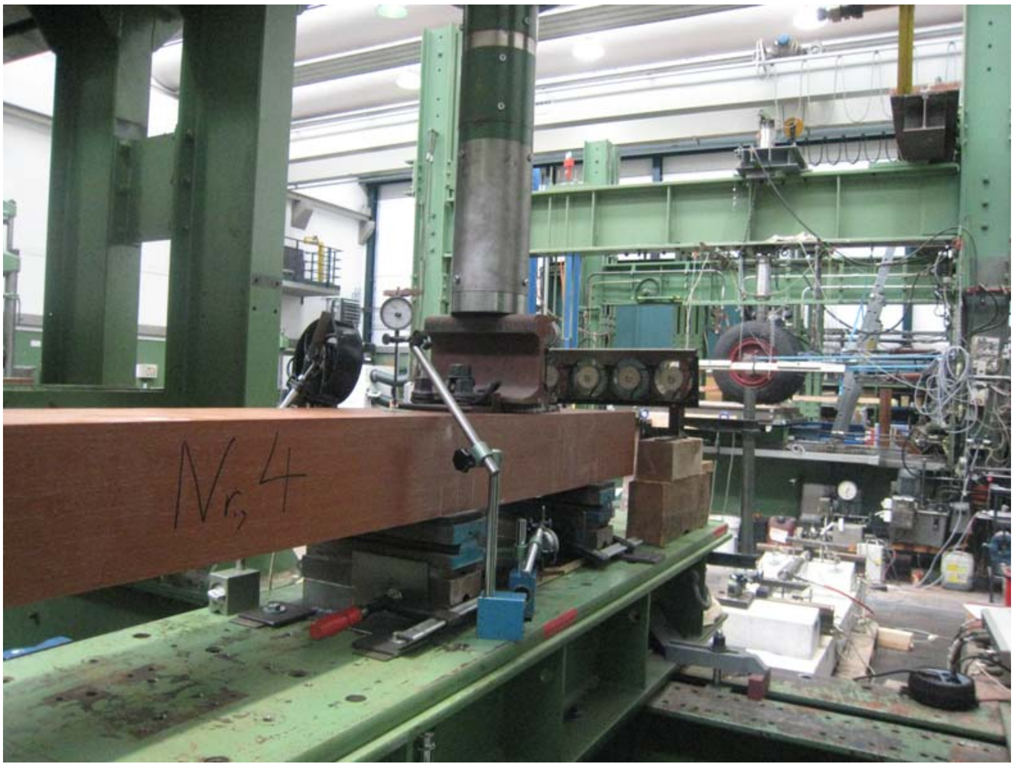
Wooden sleeper

Static test in sleeper centre

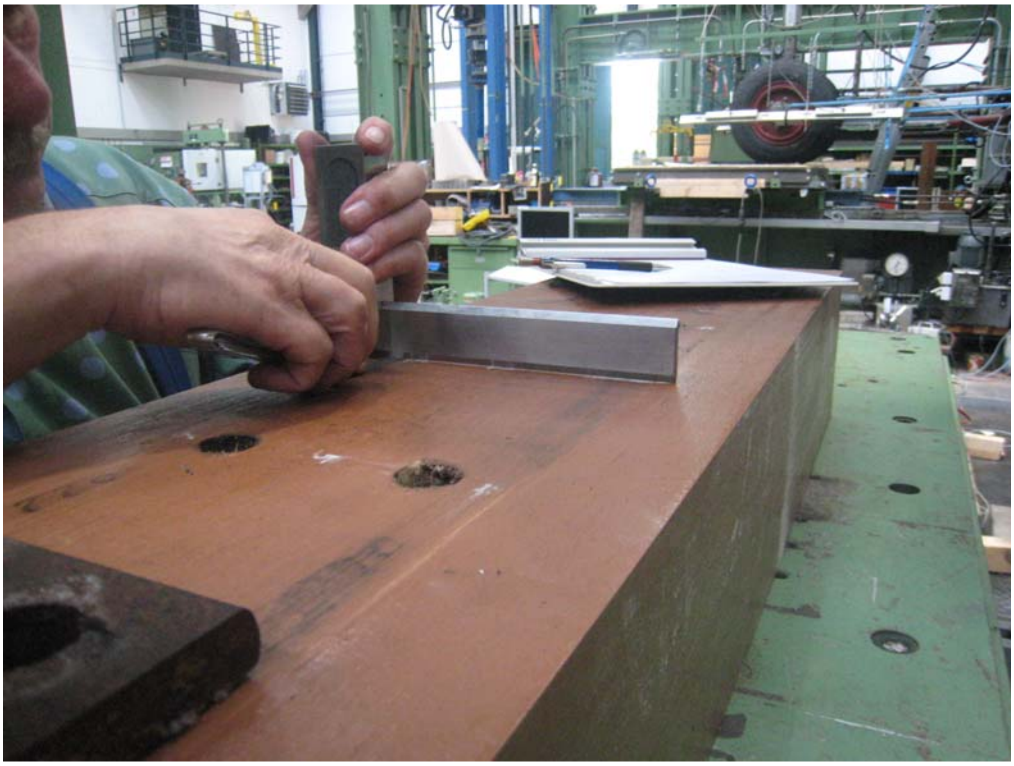


Fatigue test in sleeper centre





Fatigue test under rail seat



Static compression test (see chapter 2.9)