# UIC type A axle 20 t + high performance operation (overload) clarification

*Joint Sector Support Group for ERA Task Force on wagon/axle maintenance*
*Brussels*
*02nd December 2009*

# Summary for type A axles in high performance operation

- **UIC type A axle is operated within the allowed frame of the national technical rules**
- **UIC type A axle operational experience demonstrates safe service**
- The sector decided **nevertheless** to continuously download the type A I+II axles from 21t to 20t axle load to increase further the operational safety
- The standard operation of the geometrically different type A III (2) axles at 20,6t axle load is continuously allowed under special maintenance or technical conditions (currently applied in France and Belgium, explanation given in annexed slides)
- To increase safety further, the worn diameter in the wheel seat during changing the weels will be limited to **182 mm** if wheelset is operated at 20t axle load

# UIC type A axle is operated within the allowed frame of the national technical rules

- UIC type A axle drawings standardisation based on SNCF drawing (1956) and DB drawing (1958**)**
- Wheel seat drawing (nominal) diameter was set to **185 mm**
- Maintenance limit values for the wheel seat differ over Europe, going down to **180 mm**
- Allowance of 180 mm for wheel seat in maintenance considered in UIC 515-3 (1994)
- Former technical rules (before creation of ERRI/ORE and EN calculation standards) have been the base for UIC type A axle design and have to be considered
- New standards are not applicable to old design (clarification by EN 13103 authors has been given)
- Accepted non-conformity to new standards w/o consequence in written for wheels (UIC 510-5)

- SNCF (1976 rule) and DB (1960 Fw 28.02.08) calculations show that 20t are acceptable for all wheel seat diameters
- SNCF calculat. (1976 rule) shows feasibility of 20,6t type A III (2) @wheel seat diam **183 mm**
- DB calcul. (1960 Fw 28.02.08) shows feasibility of 21t type A I+II @wheel seat diam **182 mm**
- In all calculation schemes, all considered parameters (accumulated) are set to worst case

# UIC type A axle operational experience demonstrates safe service

- UIC type A operating experience of more than **1.100.000** axles Type A (= more than 2/3 of the total European freight axle population)
  - ✓ at 20t in Europe over the last 50 years
  - ✓ at 20,6t (SNCF+SNCB) since 1990 (19 years)
  - ✓ at 21t since 1985 (ex-GDR) and 1994 (german sector)

- As it regards loads, the most critical regions are the end of the wheel seat or the transition radii (depending on axle geometry)
- Only two accidents (of over 1 Million axles) in 2006 up to now of known failures in the critical regions: (1. case: material insufficiency; 2. case: no design problem)
- Incidents in other A axle regions are not a problem of design/calculation (i. e. not due to fatigue)
- If systematic failure in concept/design/maintenance, a much higher number of incidents would occur
- "Homologation through operation" is a widely accepted approach by many EU NSAs

# High performance operating prescriptions (overload)

# Existing operational load maintenance conditions

| | Definition<br>UIC type A axle (all) | Maintenance measures |
|---|---|---|
| UIC 510-1 | 20 t Standard | None |
| SNCF: | 1) Operational load not exceeding design load >10%<br><br>2) Occasional overload exceeding design load >10%<br>**design load for type A III (2) is 20,6 t** | 1) Parc SUR / 200 kkm<br>- UT (wheel seat)<br>- MT surface<br>2) Scrap axle |
| SNCB: | 1) Operational load not exceeding 20,6t<br><br>2) Occasional overload exceeding design load >10% | 1) Parc SUR / 400 kkm/5 y<br>- UT (wheel seat)<br><br>2) Scrap axle |
| DB / VPI: | 1) Operational load not exceeding design load >10%<br>**Former design load for type A I+II was 21 t**<br>2) Occasional overload > 10%: | 1) None<br><br>2) heavy maintenance /<br>UT with mounted wheels |

# Proposal for EU harmonised handling of high performance load

| Definition for load limits for all axle types | Maintenance measures |
|---|---|
| **Limit for high performance operation** | **Limited mileage between heavy maintenance with or w/o changing wheels:** |
| Axle load exceeding design load < = 5%<br>(for type A:  > 20,6t up to 21t) | - 400.000 km<br>- ECM task is to define the equivalent time limit |
| Axle load exceeding design load >5%->10%<br>(for type A:  > 21t up to 22t) | - 200.000 km<br>- ECM task is to define the equivalent time limit |
| | **Both cases: NDT with mounted wheels**<br>- UT wheel seat<br>- UT or MT transition radii |
| **For type A axles operated at 21t axle load in standard maintenance plan and re-classified back to 20t operation:** | re-integrate axle in standard maintenance plan whith UT of the wheel seat at the next heavy maintenance of the wheelset (in particular reprofiling) |

## Supporting information

# Proposal for amendment of EN 13103

as agreed on in 17.11.2009 JSSG meeting

**Move to chapter 4 (General):**
This standard describes the calculation methods to apply solely for wheelsets designed after the publication of this standard.
Suitable maintenance programs for the wheelsets/axles have to be applied according to maintenance standard (EN 15313).
This standard cannot be applied to existing wheelsets / axles designed, manufactured and purchased under differing regulations in the past.

**Amend** the sentence as follows:
"These values should apply only in dimensioning new designs of axles and if the protection and maintenance policy applied to the axle follows the requirements laid down in the maintenance standards (EN 15313), in order to ensure the effectiveness of the protection against impacts and corrosion throughout the life of the axle."

**delete:** "…and ensures that the original surface condition of the axle material is maintained."

**Amend** the sentence as follows:
"If the wheelset/axle protection against impacts and corrosion does not comply with the maintenance standard EN 15313, then the permissible stresses shall be divided by an additional factor (see following NOTE).
*Note: The additional security coefficient should be agreed by the designer and the vehicle operator, taking into account the operator´s maintenance policy. For example: an additional factor of the order of 1,3 should be used for grades EA1N, EA1T and EA4T..."*

# UIC 510-1 type A axle

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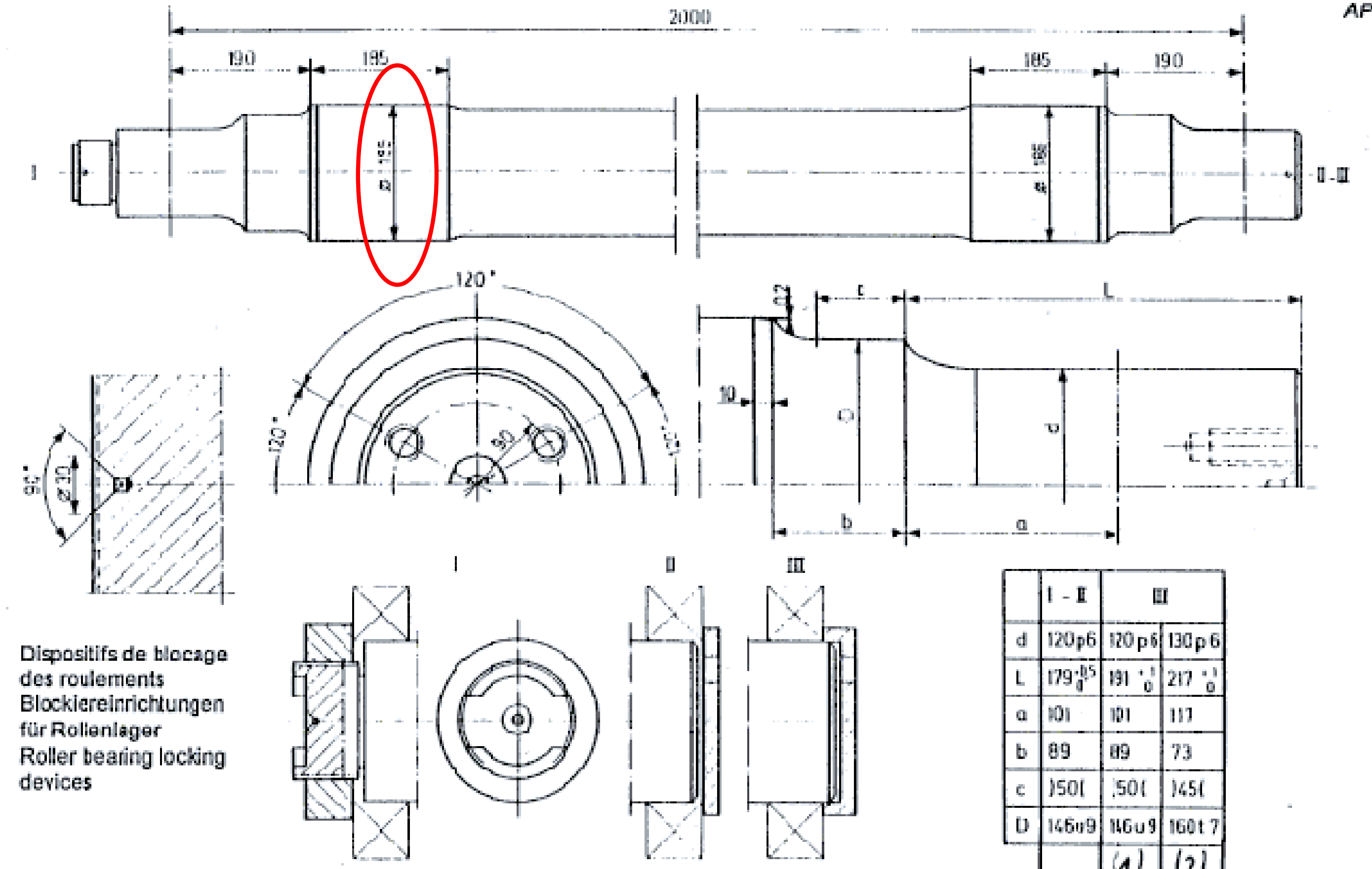
- 11 -

Essieu type A - Radsatzwelle bauart A - Axle, type A

*ANNEXE 1*
*ANLAGE 1*
*APPENDIX 1*




| | I - II | III | |
|---|---|---|---|
| d | 120p6 | 120 p 6 | 130 p 6 |
| L | $179^{+0.5}_{0}$ | $191^{+1}_{0}$ | $217^{+1}_{0}$ |
| a | 101 | 101 | 117 |
| b | 89 | 89 | 73 |
| c | 150 | 150 | 145 |
| D | 146u9 | 146u9 | 160t7 |
| | | (1) | (2) |

(1) Standardisation
(2) Unification

01-07-94

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# Different UIC type A axles in Europe (not exhaustive)

| | type | Jour-nal | abutment | | Wheel Seat | Transition radius | shaft | No of A axles |
|---|---|---|---|---|---|---|---|---|
| **ÖBB** | A I-II | 120 | 146 | new | 185 | 15 + 75 | 160 +2/-0 (new design 163 +2/-0) | **21.000** |
| | 20t (21 t) | 119 | 146 | Limit | 181 | | 160,0 | |
| **DB D** | A | 120 | 146 | new | 185 | 15 + 75 | 160 +2 | **180.000** |
| | 20t (21 t) | 119 | 145 | Limit | 182 | | 158 | |
| **TI** | A III-2 | 130 p6 | 160 t7 | new | 185 | 20 + 100 | 165 +2 | **80.000** |
| | 20t | 130 | 160 t7 | Limit | 180 | | 161 | |
| **SBB** | A I | 120 p6 | 146 u8 | new | 185 m6 | 15 + 75 | 160 +/-0,5 | **7.000** |
| | 20t | 120 p6 | 146 u8 | Limit | 184 m6 | | 160 +/-0,5 | |
| **SNCB** | A III-2 | 130 p6 | 160 t7 | new | 190 v6 | 15 + 75 | 165 +2 after 1989 (before: 160) | **30.000** |
| | 20 t (SUR: 20,6) | 130 p6 | 160 t7 | Limit | 185 | | 162 | |
| **SNCF** | A III-2 | 130 p6 | 160 t7 | new | 185 | 15 + 75 | 170 | **200.000** |
| | 20t<br>(20,6 ; SUR:22,0) | 130 p6 | 159 t7 | Limit | 183 | (old: 25) | 170 | |
| **PKP** | A I+II<br>A III | 120<br>130 | 146<br>160 | new | 185 | 15 + 75 | 160 +2 | **256.700** |
| | | | | limit | 183 | | | |
| **UIP** | „all types“ | | | | | | | **350.000** |
| | | | | | | | **Sum EU ca. >** | **1.100.000** |

# 20,6 t calculation SNCF (1)

## ESSIEU A FUSEES EXTERIEURES

*Calculé suivant la NE MR 4 R 1 n°1 de 1976*

ESSIEU DE VOITURE INCORPORE DANS UNE RAME OU ESSIEU DE WAGON

| | |
|---|---|
| **Type** | 9052 |
| **Dessin d'essieu** | 10-344 867 |
| **Dessin de roue** | 10-448 550 |
| **Affectation** | Wagon |
| **Matière** | A1N |

**MASSE SUR RAIL PAR ESSIEU (Mo) : 20 600 kg**

**MASSE DE L'ESSIEU MONTE**

| | |
|---|---|
| **Essieu-axe** | 375 kg |
| **Roues** | 657 kg |
| **Pont moteur** | kg |
| **Disques** | kg |
| **Divers** | kg |
| **Total (mo)** | **1 032 kg** |

**DIMENSIONS**

| | |
|---|---|
| b = | 250 mm |
| L = | 1 500 mm |
| R = | 460 mm |

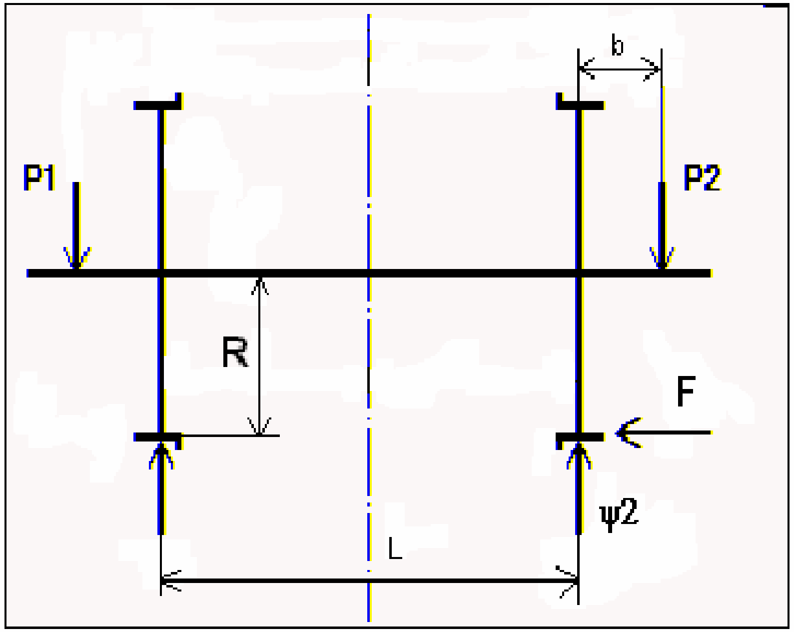
# 20,6 t calculation SNCF (2)

EFFORTS EN N

| | | |
|---|---|---|
| **P =** | Mo/2 | 101043 |
| **Po =** | (Mo-mo)/2 | 95981 |
| **P1 =** | 0,5 Po | 47991 |
| **P2 =** | 1,5 Po | 143972 |
| **F =** | 0.6 Po | 57589 |
| **ψ2 =** | [P2 x (b+l) - P1 x b + F x R] / L | 177629 |

RAPPORTS

| | | |
|---|---|---|
| **d1o** | 185. mm | |
| **d1u** | 183. mm | |
| **d** | 170. mm | |
| **Section** | **d1o / d** | **d1u / d** |
| 4 | 1.09 | 1.08 |

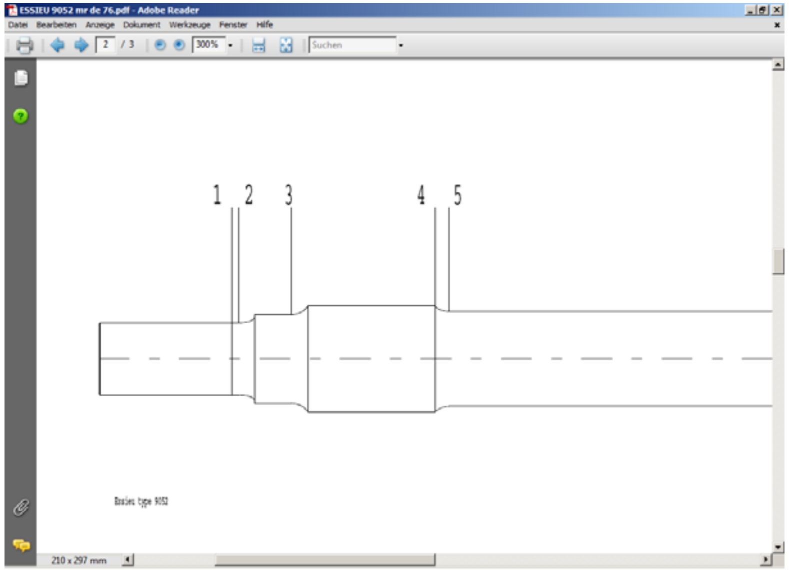



FREINAGE

| Type de Freinage | SABOT | DISQUE |
|---|---|---|
| **Ff** | 30313 N | 0 |

**Sabots frottant des deux cotés de la roue**

# 20,6 t calculation SNCF (3)




| Section | X | d | D | r | K | 32K x 10^6 x d / π x (d^4-d'^4) | Mv (mm.N) / 10^6 | M'h (mm.N) / 10^6 | M't (mm.N) / 10^6 | MR (mm.N) / 10^6 | σ (N/mm²) | σ max (N/mm²) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 86 | 130 | 130 | | 1 | 4.636 | 12.382 | 2.607 | 0 | 12.653 | 58.66 | 100 |
| 2 | 95.5 | 129.8 | 160 | 40 | 1.02 | 4.751 | 13.749 | 2.895 | 0 | 14.05 | 66.75 | 166 |
| 3 | 168.35 | 160 | 285 | 25 | 1.222 | 3.039 | 24.238 | 5.103 | 0 | 24.769 | 75.27 | 166 |
| 4 | 371 | 185 | 185 | | 1 | 1.609 | 58.411 | 7.578 | 13.944 | 60.529 | 97.39 | 100 |
| 5 | 389 | 170 | 250 | 25 | 1.154 | 2.393 | 57.805 | 7.578 | 13.944 | 59.944 | 143.45 | 166 |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |

Essieu type 9052

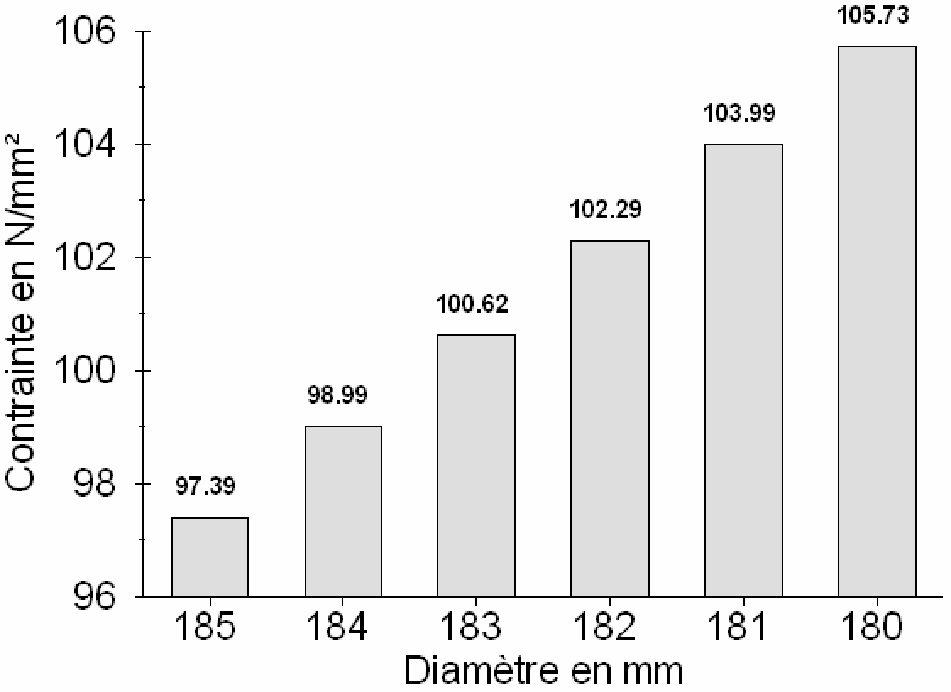
07-Mar-2003

# 20,6 t calculation SNCF (4)

**ESSIEU MONTE TYPE : 9052**

Section : 4

Contrainte maximale autorisée : 100 N/mm²



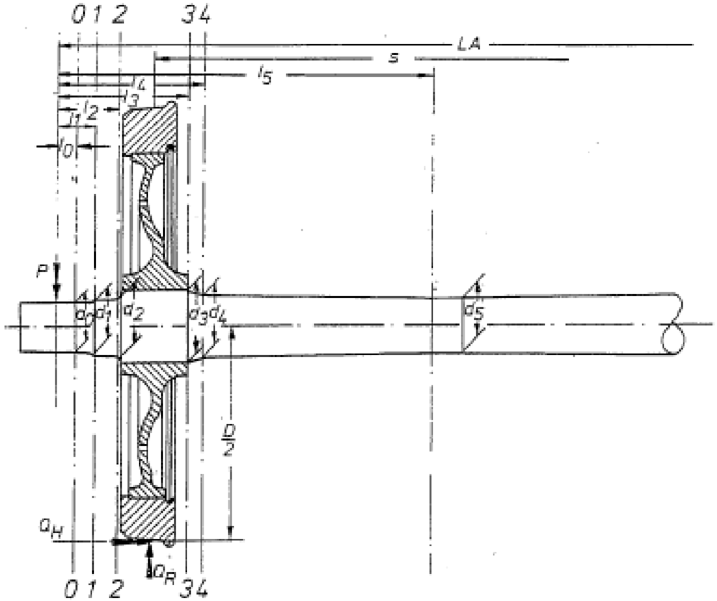
# 21 t calculation DB (1)

## Achswellenberechnung für Laufradsätze mit Vollwellen

### 1. Allgemeine Angaben

| | | |
|---|---|---|
| Wagenbauvertrag: | | |
| Wagenart: | Güterwagen | |
| Höchstgeschwindigkeit: | 120 | km/h |
| Radsatzhersteller: | | |
| Radsatzzeichnung: | 37 Fw 663.0.02.002.005 | |
| Gesamte Achslast [1] $Q_A$: | 21.000 | kg |
| Radsatzgewicht $G$ | 967 | kg |
| Achsschenkelbelastung [2] $P_S = Q_A - G$ | 20.033 | kg |

vergl. Seite 1, 2 u. 4 der anhängenden ausführlichen Berechnung




### 2. Hauptabmessungen des Radsatzes

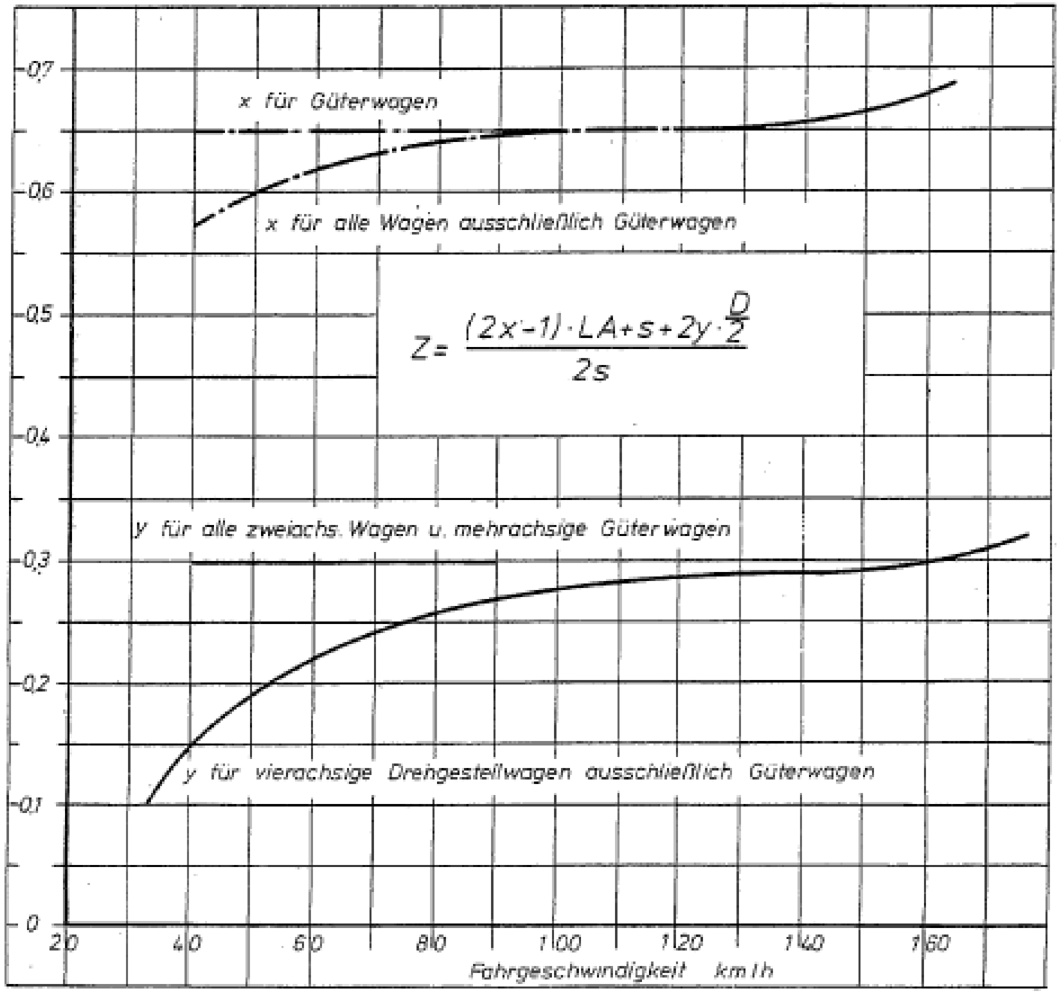
| | | | |
|---|---|---|---|
| Federbundmittenabstand = Achslagermittenabstand | $LA$ = | 200,00 | cm |
| Laufkreishalbmesser | $\frac{D}{2}$ = | 46,00 | cm |
| Abstand der Laufkreisebenen | $s$ = | 150,00 | cm |
| Achsschenkelmitte - Lagereinspannstelle [3] | $l_0$ = | 6,95 | cm |
| Achsschenkelmitte - Notlaufsitz | $l_1$ = | 10,10 | cm |
| Achsschenkelmitte - Nabensitzrand außen | $l_2$ = | 18,50 | cm |
| Achsschenkelmitte - Nabensitzrand innen | $l_3$ = | 37,00 | cm |
| Achsschenkelmitte - Achsschaftanfang | $l_4$ = | 40,50 | cm |
| Achsschenkelmitte - Achsmitte | $l_5$ = | 100,00 | cm |

1) Falls nicht vorgeschrieben, ist die Ermittlung besonders nachzuweisen, wobei das Gesamtgewicht des Wagens nach den für jede Wagenart gültigen Entwurfsvorschriften zu berechnen ist.
2) $P_S$ = ruhende Achsschenkelbelastung 3) Nur für Rollenlager

| | | | |
|---|---|---|---|
| Lagersitzdurchmesser | $d_0$ | 12,0 | cm |
| Widerstandsmoment | $W_0$ | 169,65 | $cm^3$ |
| Achsschenkeldurchmesser | $d_1$ | 12,0 | cm |
| Widerstandsmoment | $W_1$ | 169,65 | $cm^3$ |
| Durchmesser des Notlaufsitzes | $d_2$ | 14,6 | cm |
| Widerstandsmoment | $W_2$ | 305,53 | $cm^3$ |
| Nabensitzdurchmesser | $d_3$ | 18,2 | cm |
| Widerstandsmoment | $W_3$ | 591,85 | $cm^3$ |
| Achsschaftdurchmesser | $d_4$ | 15,8 | cm |
| Widerstandsmoment | $W_4$ | 387,23 | $cm^3$ |
| Achsmittendurchmesser | $d_5$ | 15,8 | cm |
| Widerstandsmoment | $W_5$ | 387,23 | $cm^3$ |

# 21 t calculation DB (2)

3. Kurvenbild für Beiwerte *(für Wagen mit normaler Spurweite)*




## 4. Die am Radsatz angreifenden Kräfte:

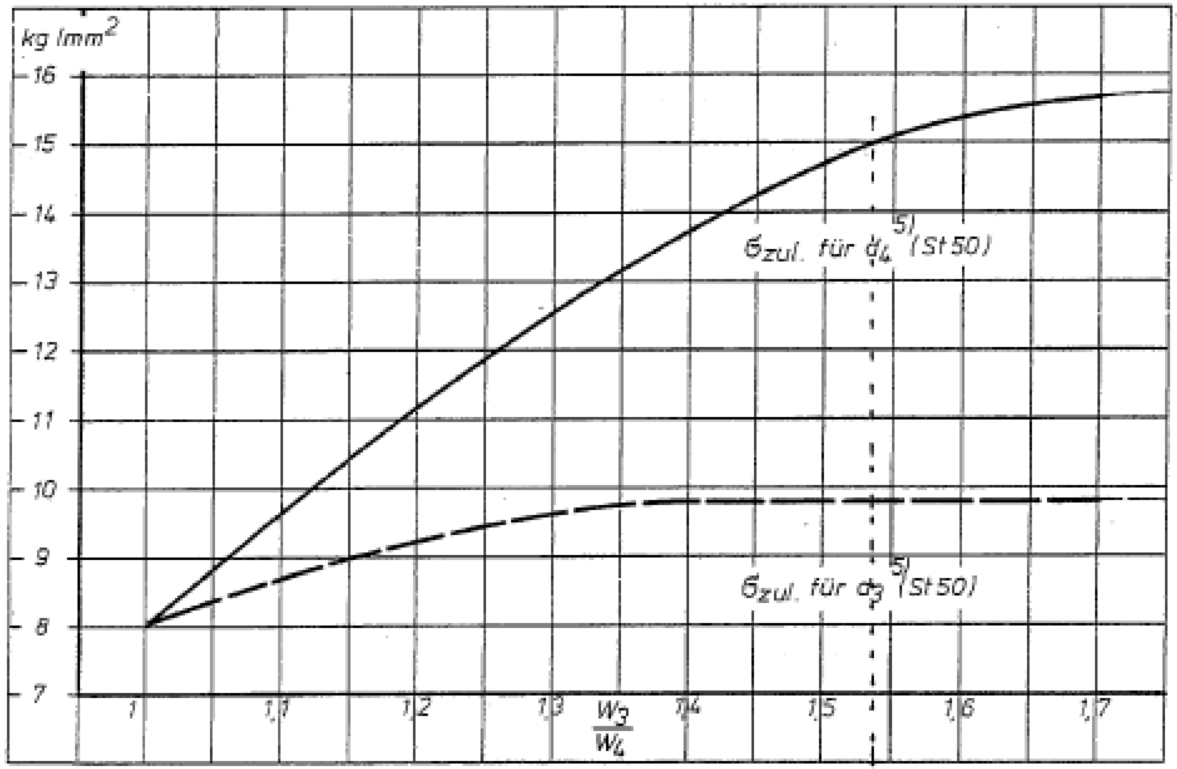
| | | | | |
|---|---|---|---|---|
| Achsschenkelbelastung $P_{sd}$ | $P_{sd} = x \cdot P_S$ | 13.021 | kg | In den Beiwerten x und z ist der Einfluß der Seitenkraft $Q_H$ auf die Achsschenkelbelastung und den Raddruck bereits berücksichtigt |
| Seitenkraft $Q_H$ | $Q_H = y \cdot P_S$ | 6.010 | kg | |
| Gesamtraddruck $Q_R$ | $Q_R = z \cdot P_S$ | 15.866 | kg | |

## 5. Die Biegungsmomente:

| | | |
|---|---|---|
| $M_0 = P_{sd} \cdot l_0$ | 90.496 | cmkg |
| $M_1 = P_{sd} \cdot l_1$ | 131.512 | cmkg |
| $M_2 = P_{sd} \cdot l_2$ | 240.889 | cmkg |
| $M_3 = P_{sd} \cdot l_3 + Q_H \cdot \frac{D}{2} - Q_R \left(l_3 - \frac{LA - s}{2}\right) =$ | 567.845 | cmkg |
| $M_4 = P_{sd} \cdot l_4 + Q_H \cdot \frac{D}{2} - Q_R \left(l_4 - \frac{LA - s}{2}\right) =$ | 557.888 | cmkg |
| $M_5 = P_{sd} \cdot l_5 + Q_H \cdot \frac{D}{2} - Q_R \left(l_5 - \frac{LA - s}{2}\right) =$ | 388.610 | cmkg |

# 21 t calculation DB (3)

6. Kurvenbild für zulässige Spannungen:




[5] Die Werte für $\sigma'_{zul.}$ gelten nur für den günstigsten Übergangsbogen vom Nabensitz zum Achs-schaft, und zwar bei $\frac{W_3}{W_4} < 1{,}3$ für einen Ausrundungshalbmesser von $r = 15$ mm und bei $\frac{W_3}{W_4} \geqq 1{,}3$ für einen Korbbogen mit einem Ausrundungshalbmesser von $r = 15$ mm an der Nabe beginnend und im Schaft mit 75mm auslaufend

Verhältnis der Widerstandsmomente: $\frac{W_3}{W_4} = \frac{591{,}85}{387{,}23} = 1{,}528$

# 21 t calculation DB (4)

7. Die Spannungen

| | $\sigma_{zul.}$ in kg/mm² | |
|---|---|---|
| | St 50 | St 65 |
| $\sigma_0 = \frac{M_0}{W_0} = \frac{90.496}{169,65} = 533,44 \frac{kg}{cm^2} = 5,33 \frac{kg}{mm^2}$ | 8,00 | |
| $\sigma_1 = \frac{M_1}{W_1} = \frac{131.512}{169,65} = 775,21 \frac{kg}{cm^2} = 7,75 \frac{kg}{mm^2}$ | 12,00 | |
| $\sigma_2 = \frac{M_2}{W_2} = \frac{240.889}{305,53} = 788,42 \frac{kg}{cm^2} = 7,88 \frac{kg}{mm^2}$ | 12,00 | |
| $\sigma_3 = \frac{M_3}{W_3} = \frac{567.845}{591,85} = 959,44 \frac{kg}{cm^2} = 9,59 \frac{kg}{mm^2}$ | 6) 9,85 | 6) |
| $\sigma_4 = \frac{M_4}{W_4} = \frac{557.888}{387,23} = 1440,71 \frac{kg}{cm^2} = 14,41 \frac{kg}{mm^2}$ | 6) 15,00 | 6) |
| $\sigma_5 = \frac{M_5}{W_5} = \frac{388.610}{387,23} = 1003,56 \frac{kg}{cm^2} = 10,04 \frac{kg}{mm^2}$ | 16,00 | |

6) Wert aus dem Kurvenbild Nr. 6 entnehmen und eintragen

| | |
|---|---|
| Aufgestellt am: 26.11.09<br>Firma: Deutsche Bahn<br>772 223<br>Michael Gerstner | Geprüft und nachgerechnet:<br>BZA........den.......... |
| (Gültigkeitsvermerk) | Deutsche Bundesbahn<br>Fw 28.02.8<br>8. Ausgabe vom 10. 3 1960 |

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# UIC 515-3 calculation schemes (1994) confirm indirectly wheel seats diameter down to 180 mm in maintenance (type A)

| Durchmesser von Sitz D | Durchmesser von Radsatz-schaft d | Beziehung $\frac{D}{d}$ | D - 5 | $\frac{D - 5}{d}$ |
|---|---|---|---|---|
| 180 | 155 | 1,16 | 175 | 1,13 |
| 185 | 160 | 1,16 | 180 | 1,12 |
| 190 | 165 | 1,15 | 185 | 1,12 |
| 195 | 170 | 1,15 | 190 | 1,12 |

(1) D + 5 und D - 5 verstehen sich als Grenzmaße der Nabensitze im Anschluß an Instandhaltungsarbeiten

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## Thank you for your attention!