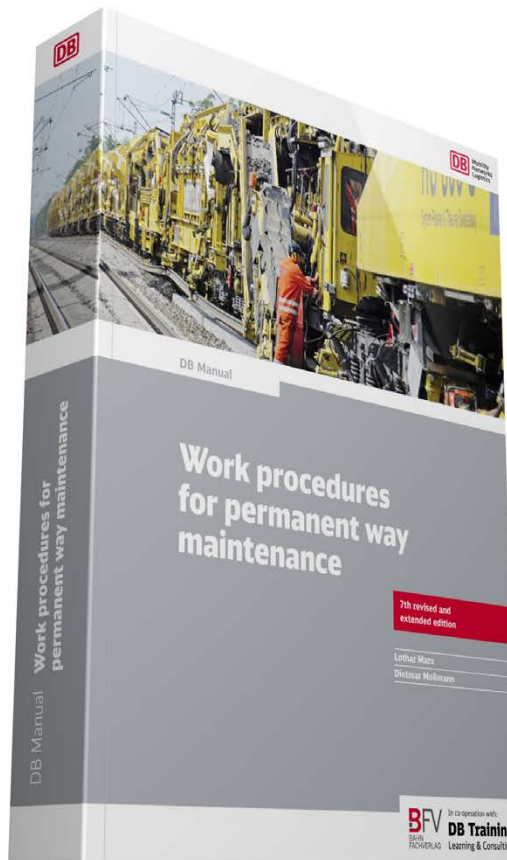


DB Manual

Work procedures for permanent way maintenance



CONTENTS

Contents

| | |
|--|-----------|
| Preface | 19 |
| 1 General | 21 |
| 2 Track equipment | 25 |
| 2.1 General | 25 |
| 2.2 The rails | 25 |
| 2.2.1 Insulated rails | 26 |
| 2.2.2 Insulated joints | 26 |
| 2.3 The sleepers | 28 |
| 2.3.1 The wooden sleepers | 28 |
| 2.3.2 The steel sleepers | 28 |
| 2.3.3 The reinforced concrete sleeper | 30 |
| 2.3.4 Special forms of concrete sleeper | 31 |
| 2.4 The sleepers of the ballastless track system | 32 |
| 2.5 The rail fastening | 35 |
| 2.5.1 The rail pad | 35 |
| 2.5.2 The types of rail fastening | 35 |
| 2.6 The ballast bed | 41 |
| 3 Substructure | 43 |
| 3.1 General | 43 |
| 3.2 Substructure of new tracks | 45 |
| 3.2.1 Substructure foundation | 46 |
| 3.2.2 Checking load-bearing capability and rate of compression | 47 |
| 3.2.3 Measures to prevent embanking settling | 47 |

| | | |
|------------|---|-----------|
| 3.2.4 | Draining the track formation | 48 |
| 3.2.5 | Drainage systems | 48 |
| 3.3 | Substructure of old tracks | 49 |
| 3.3.1 | Substructure remediation | 50 |
| 4 | Line layout and routing | 51 |
| 4.1 | General | 51 |
| 4.2 | Principles of line layout: Discretionary and approval limit values | 51 |
| 4.3 | Route elements | 52 |
| 4.4 | Fundamentals of routing | 52 |
| 4.4.1 | The curved track | 52 |
| 4.4.2 | Superelevation | 53 |
| 4.4.3 | Lateral acceleration | 53 |
| 4.4.4 | Compensating superelevation | 53 |
| 4.4.5 | Determining superelevation | 53 |
| 4.4.6 | Unbalanced superelevation | 54 |
| 4.4.7 | Excess of superelevation | 55 |
| 4.4.8 | Minimum superelevation | 55 |
| 4.4.9 | Standard superelevation | 56 |
| 4.5 | Transition curves and superelevation ramps | 56 |
| 4.5.1 | The transition curve | 56 |
| 4.5.2 | Reverse curve with transition curve | 56 |
| 4.5.3 | Superelevation ramps | 57 |
| 4.5.4 | Ramp forms | 57 |
| 4.6 | Longitudinal track pull | 58 |
| 4.7 | Slope and gradient change | 59 |
| 4.7.1 | Graduated gradient change | 59 |
| 5 | Maintenance terms | 60 |

| | | |
|------------|---|------------|
| 5.1 | General | 60 |
| 5.2 | Explanation of individual terms and meaning for the permanent way | 60 |
| 6 | Inspection | 63 |
| 6.1 | Inspections on foot/inspection runs | 63 |
| 6.1.1 | Track inspections on foot | 63 |
| 6.1.2 | Track inspection runs (see guideline 821.2004) | 64 |
| 6.2 | Measurement runs | 65 |
| 6.2.1 | Checking the track geometry with track inspection vehicles (see guideline 821.2001) | 65 |
| 6.2.2 | Technical driving inspections (see guideline 821.2002) | 71 |
| 6.2.3 | Ultrasonic test runs | 73 |
| 6.2.4 | Rail inspection train equipment | 77 |
| 6.3 | Manual measurements | 79 |
| 6.3.1 | Switch diagnosis system VAE ROADMASTER 2000 | 81 |
| 6.4 | Foundation survey | 84 |
| 6.4.1 | General | 84 |
| 6.4.2 | Execution of the geotechnical survey | 85 |
| 6.4.3 | Evaluation of results | 92 |
| 6.4.4 | Construction execution | 94 |
| 6.4.5 | Conclusion | 95 |
| 6.4.6 | Application of ground-penetrating radar | 95 |
| 6.4.7 | Geotechnical survey report for maintenance work | 106 |
| 6.5 | Evaluation and measures | 112 |
| 6.5.1 | General | 112 |
| 6.5.2 | Integrated inspection system (IIS) | 112 |
| 6.5.3 | Near-surface defects in rails | 121 |
| 6.5.4 | Planning of measures for track maintenance (see guideline 823.0100A02) | 125 |
| 6.5.5 | Special inspections with the GeoRail Xpress | 131 |
| 7 | Servicing | 137 |

| | | |
|------------|--|------------|
| 7.1 | Weed killing on and alongside railway tracks | 137 |
| 7.1.1 | Weed killing on railway tracks using pesticides | 138 |
| 7.1.2 | Weed killing outside of tracks using mechanical procedures | 140 |
| 7.2 | Lubrication of slide base plates | 142 |
| 7.2.1 | Lubrication of slide base plates | 142 |
| 7.2.2 | Switch rollers | 142 |
| 7.2.3 | Switch roller systems | 142 |
| 8 | Repair work | 146 |
| 9 | Planning of track maintenance | 148 |
| 9.1 | Rail transport | 158 |
| 9.1.1 | Quality assurance when loading rails | 158 |
| 9.1.2 | Rail transport with Robel design type | 162 |
| 9.1.3 | Rail transport with STS design type | 164 |
| 9.1.4 | Mobile continuous welded rail unloading device Geismar design type, model EMD | 166 |
| 9.2 | High-speed track renewal machine SUM 315 (Q 3) | 168 |
| 9.3 | Track renewal train Matisa | 175 |
| 9.3.1 | Overview of the track renewal train procedure | 175 |
| 9.3.2 | Special features of track renewal trains UM-1, 2 and 3 | 183 |
| 9.3.3 | Special features of track renewal train UM-S 2001 (HENRY THE STRONG) | 185 |
| 9.3.4 | Special features of P 95-2008 UM and UM-P from Schweerbau | 189 |
| 9.3.5 | Track renewal train MATISA P 90 LS from JumboTec | 192 |
| 9.3.6 | Special features of P 95 from Strukton | 197 |
| 9.3.7 | Special features of track renewal train P 95 SR | 199 |
| 9.3.8 | Renewal procedure Matisa P 100 | 204 |
| 9.4 | High-speed track renewal machine (SUM-Q 1) | 210 |
| 9.5 | RU 800 S track renewal and ballast cleaning in one operation | 213 |
| 9.5.1 | General | 213 |
| 9.5.2 | Description of the working method | 215 |

| | | |
|-------------|--|------------|
| 9.6 | High-performance renewal procedure VFW 2001 | 217 |
| 9.7 | Track renewal in a two-sleeper cycle with the SUZ 500 UVR | 221 |
| 9.8 | Track renewal train SUZ 500 with SVM 98 | 226 |
| 9.8.1 | Preconditions for using the SUZ 500 | 226 |
| 9.8.2 | Preliminary work | 227 |
| 9.8.3 | Organisation | 227 |
| 9.8.4 | Special circumstances | 228 |
| 9.8.5 | Track renewal with SUZ 500 | 228 |
| 9.8.6 | Subsequent operations (not usually by high-speed track renewal train personnel) | 230 |
| 9.8.7 | Unloading and forwarding the continuous welded rails with the rail forwarding machine in combination with high-speed track renewal train SUZ 500 | 231 |
| 9.9 | Donelli portal crane | 231 |
| 9.10 | Track assembly | 234 |
| 10 | Renewal of switches | 240 |
| 10.1 | General | 240 |
| 10.2 | Preconditions (unloading, assembly) | 243 |
| 10.3 | Revolving cranes | 251 |
| 10.4 | Renewal machine unit for switches and tracks | 260 |
| 10.5 | Switch renewal with switch renewal machine WM 500-U | 262 |
| 10.6 | Switch transport wagon | 266 |
| 10.7 | Ready-to-install, fully-assembled large switch parts from the switch supplier | 268 |
| 10.7.1 | Objectives | 268 |
| 10.7.2 | Technical solution | 268 |
| 10.7.3 | Complete assembly in the switch factory | 270 |
| 10.7.4 | Loading and transport | 270 |

| | | |
|-------------|---|------------|
| 10.7.5 | Installation | 272 |
| 10.7.6 | Operations technology advantages | 273 |
| 10.7.7 | Special features of the complete assembly, its transport and installation | 273 |
| 10.7.8 | Summary | 276 |
| 10.8 | Switch maintenance | 277 |
| 10.8.1 | Switch inspection | 279 |
| 10.8.2 | Individual replacement of parts of the switch track | 287 |
| 10.9 | The locking sleeper | 291 |
| 11 | Sleeper replacement | 293 |
| 11.1 | General | 293 |
| 11.2 | Track renewal trains | 293 |
| 11.3 | Individual sleeper replacement by hand or with equipment | 294 |
| 12 | Rail replacement | 299 |
| 12.1 | General | 299 |
| 12.2 | Rail replacement with rail changers | 300 |
| 12.3 | Rail replacement with roller grips | 302 |
| 12.4 | Rail replacement with the rail replacement system SR | 303 |
| 13 | Ballast laying | 305 |
| 13.1 | General | 305 |
| 13.2 | Classic procedure | 309 |
| 13.3 | Ballast bed finisher | 311 |

| | | |
|-------------|--|------------|
| 14 | Installation of tracks | 312 |
| 14.1 | General | 312 |
| 14.2 | Ballast superstructure | 312 |
| 14.2.1 | Track laying with VFW 2001 | 312 |
| 14.2.2 | Track laying with SUZ 500 UVR | 313 |
| 14.2.3 | Niemaq track renewal crane | 314 |
| 14.2.4 | Renewal machine unit for switches and tracks | 315 |
| 14.2.5 | Portal crane with integrated single sleeper laying device (PK 1-20/24) | 317 |
| 14.2.6 | Track laying with revolving cranes | 319 |
| 14.2.7 | Track laying with the portal crane (Donelli) | 319 |
| 14.2.8 | Laying of individual sleepers | 319 |
| 14.3 | Ballastless track system | 321 |
| 14.3.1 | General | 321 |
| 14.3.2 | The ballastless track system design types | 323 |
| 14.3.3 | Ballastless track system laying procedures | 349 |
| 14.3.4 | Measurement of the ballastless track system with the Hergie system | 386 |
| 14.3.5 | Laying the lean-mixed concrete in ballastless track systems | 393 |
| 14.3.6 | Procedure for laying continuous welded rails in ballastless track systems | 397 |
| 14.4 | Switches in ballastless track systems | 399 |
| 14.4.1 | Switches in the RHEDA 2000® design type ballastless track system | 406 |
| 14.5 | Requirements on the substructure for ballastless track systems on earthwork foundations | 409 |
| 14.6 | Transitions | 409 |
| 14.7 | Noise insulation in ballastless track system construction | 409 |
| 14.8 | Maintenance and renewal of the ballastless track system | 412 |
| 14.9 | Laying of special sleepers | 414 |
| 14.9.1 | Y-steel sleeper superstructure Y/S15 | 414 |
| 14.9.2 | Twin sleeper | 418 |
| 14.9.3 | Sleeper bed for the ballast superstructure (padded sleeper) | 423 |

| | | |
|-------------|--|------------|
| 15 | Ballast solidification through plastic bonding | 425 |
| 15.1 | Product | 425 |
| 15.2 | Application areas | 426 |
| 15.3 | Required boundary conditions | 430 |
| 15.4 | Acceptance, quality control, guarantee | 430 |
| 15.5 | Guarantee | 430 |
| 15.6 | Work specifications | 431 |
| 15.7 | Handling of the bonding during tamping work | 431 |
| 16 | Ballast cleaning | 432 |
| 16.1 | General | 432 |
| 16.2 | Ballast cleaning machines RM 80 and 80-92 | 435 |
| 16.3 | Ballast cleaning machine RMW 1500 | 441 |
| 16.3.1 | General | 441 |
| 16.3.2 | Ballast bed cleaning with the RMW 1500 | 442 |
| 16.4 | Rail-mounted ballast cleaning machines RM 800 and RM 800 Super 3S | 446 |
| 16.5 | Rail-mounted ballast cleaning machines RM 801 and RM 801-2 | 451 |
| 16.6 | High-performance ballast cleaning machines RM 900 S and RM 900 | 456 |
| 16.6.1 | RM 900 S from SPITZKE AG | 456 |
| 16.6.2 | RM 900 from Schweerbau | 460 |
| 16.7 | High-performance ballast cleaning machine RM 95-700 | 463 |
| 16.8 | High-performance ballast cleaning machine RM 95-800 W | 468 |

| | | |
|--------------|---|------------|
| 16.9 | Rail-mounted ballast cleaning machine RM 76 UHR | 473 |
| 16.10 | Road-rail ballast cleaning machine ZRM 79 | 474 |
| 16.11 | Ballast cleaning using other procedures | 475 |
| 17 | Loading and unloading systems for waste removal and ballast laying | 476 |
| 17.1 | General | 476 |
| 17.2 | Material conveyor and hopper unit (MFS 38, 40, 100-S, 250), belt storage device (BSG 60), bulk freight hopper wagon (BSW 11000 and 2000) and road-rail MFS | 476 |
| 17.3 | Loading belts and systems | 481 |
| 17.4 | Unloading systems for laying ballast | 483 |
| 18 | Formation rehabilitation | 485 |
| 18.1 | General | 485 |
| 18.2 | Installation with earth-moving machines | 485 |
| 18.3 | Formation rehabilitation machine PM 1000-URM | 486 |
| 18.3.1 | General description of the PM 1000-URM work procedure | 486 |
| 18.3.2 | Description of the PM 1000-URM work modules | 493 |
| 18.4 | Formation rehabilitation machine PM 200-1 (BR) | 494 |
| 18.4.1 | General information on PM 200-1 | 494 |
| 18.4.2 | Addition of an RM 80-92 ballast cleaning machine to the PM 200-1 BR | 500 |
| 18.5 | Formation rehabilitation machine PM 200-2R | 501 |
| 18.5.1 | General information on PM 200-2R | 501 |
| 18.5.2 | Work procedure | 504 |
| 18.6 | Sand distribution and compacting machine (SVV 100) from Joseph Hubert and Schweerbau | 509 |

| | | |
|--------------|--|------------|
| 18.7 | Recycling and formation rehabilitation machines RPM 2002 and RPMW 2002-2 | 516 |
| 18.7.1 | Objective of RPM 2002 | 516 |
| 18.7.2 | Work procedure | 517 |
| 18.8 | Recycling, formation rehabilitation and cleaning machine RPM-RS-900 from SPITZKE AG | 522 |
| 18.8.1 | General | 522 |
| 18.8.2 | Working methods | 524 |
| 18.8.3 | RPM-RS-900 from Schweerbau | 528 |
| 18.9 | Möbius soil remediation system | 532 |
| 18.10 | Formation rehabilitation with ballast replacement – Wiebe system | 535 |
| 18.11 | Verification of installation quality | 537 |
| 19 | Mechanical tamping work in tracks and switches | 540 |
| 19.1 | Requirements on track and switch tamping machines and ballast ploughs | 540 |
| 19.2 | Measuring work ahead of tamping machines | 550 |
| 19.2.1 | Introduction | 550 |
| 19.2.2 | Measuring work on conventionally marked tracks | 551 |
| 19.2.3 | Measuring work with the EM-SAT track survey system | 553 |
| 19.2.4 | Measuring work with the GEDO CE | 560 |
| 19.2.5 | Measuring work with the Amberg GRP 3000 survey system | 565 |
| 19.2.6 | The satellite-supported track survey during track maintenance | 570 |
| 19.3 | Tamping | 578 |
| 19.3.1 | General | 578 |
| 19.3.2 | Compacting | 586 |
| 19.3.3 | First and second stabilisation | 586 |
| 19.3.4 | Creation of the ballast profile | 587 |
| 19.3.5 | Speed regulation after laying | 587 |
| 19.4 | Maintenance of the tracks | 589 |
| 19.4.1 | General | 589 |

| | | |
|-------------|--|------------|
| 19.4.2 | Preconditions and preliminary work | 591 |
| 19.4.3 | Elimination of long-wave track displacement on high-speed lines ($v > 160$ km/h) | 592 |
| 19.4.4 | Ballast distribution system (BDS 2000) | 592 |
| 19.5 | Maintenance of switches | 596 |
| 19.6 | Tamping work with small machines | 597 |
| 19.7 | Dynamic track stabilisation | 601 |
| 19.8 | Checking execution | 604 |
| 20 | Creation of the continuous welded rail track | 605 |
| 20.1 | General | 605 |
| 20.2 | Stress compensation | 605 |
| 20.3 | Welded joints (intermediate and final welds) | 608 |
| 21 | Elimination of individual defects | 619 |
| 21.1 | Tracks | 619 |
| 21.1.1 | General | 619 |
| 21.1.2 | Correction of track displacement | 619 |
| 21.1.3 | Gauge correction | 622 |
| 21.1.4 | Bending up retracted insulated joints | 624 |
| 21.1.5 | Sleeper rehabilitation | 625 |
| 21.2 | Elimination of individual geometry defects in tracks and switches with individual defect tamping machines | 633 |
| 21.2.1 | UNIMAT-Sprinter individual defect tamping machine | 633 |
| 21.2.2 | Fully mechanised individual defect processing with the 08-275 4ZW | 638 |
| 22 | Rail processing | 641 |
| 22.1 | General | 641 |

| | | |
|-------------|--|------------|
| 22.2 | Rail processing machines, type RR | 644 |
| 22.2.1 | Rail grinding trains, types RR 48 M and 32 M | 646 |
| 22.2.2 | Rail grinding machines, type RR 24 M | 646 |
| 22.2.3 | Universal grinding machines, types RR 16 M and RR 24 MC | 647 |
| 22.2.4 | Switch grinding machines, types RR 16 P/D and 16 MS | 647 |
| 22.3 | Rail processing machines types RG, SPML, RGM, GWM, SF 03/SM 03, SFU 04/SM 04, SBM | 650 |
| 22.3.1 | Rail grinding machine RG 48 | 650 |
| 22.3.2 | Rail grinding machine SPML 16-2 | 652 |
| 22.3.3 | Rail grinding machine RGM | 653 |
| 22.3.4 | Track and switch grinding machine GWM 550 | 654 |
| 22.3.5 | Rail milling unit SF 03/SM 03 | 656 |
| 22.3.6 | Rail milling machine SFU 04/SM 04 | 657 |
| 22.3.7 | Rail processing machine SBM 250 | 659 |
| 22.4 | Track and switch grinding machine RGH C 20 plus suction and rinsing unit (SuSE) | 661 |
| 22.5 | Rail grinding machine SZ 2000 | 665 |
| 22.6 | Rail milling unit SF 03 FFS-Plus | 668 |
| 22.7 | High-speed grinding with grinding machine RC 01 | 669 |
| 22.8 | Rail milling train SF 03 W-FFS | 671 |
| 22.9 | Hand-held grinding equipment | 675 |
| 23 | Noise insulation and vibration protection | 676 |
| 23.1 | Introduction | 676 |
| 23.1.1 | Noise and vibration caused by railway vehicles | 676 |
| 23.1.2 | Sources of noise | 677 |
| 23.1.3 | Rolling noise | 678 |
| 23.1.4 | Legal framework conditions | 679 |
| 23.1.5 | Vibration | 680 |
| 23.2 | Inspection: assessment of the actual status of the rail running table quality | 682 |

| | | |
|-------------|---|------------|
| 23.2.1 | Direct measurement processes | 682 |
| 23.2.2 | Indirect continuous measurement processes | 683 |
| 23.3 | Maintenance and repair of rail running tables | 684 |
| 23.4 | Sound-reducing measures | 685 |
| 23.4.1 | Measures on the rail | 685 |
| 23.4.2 | Absorbent running track coverings | 685 |
| 23.4.3 | Measures in the propagation path | 685 |
| 23.4.4 | Measures at the immission point | 686 |
| 23.5 | Vibration-reducing measures | 686 |
| 23.5.1 | Measures in the superstructure system | 686 |
| 23.5.2 | Measures in the propagation path | 687 |
| 23.5.3 | Measures at the immission point | 687 |
| 24 | Assessment and acceptance of track maintenance | 688 |
| 24.1 | Principles | 688 |
| 24.1.1 | General | 688 |
| 24.1.2 | Acceptance | 688 |
| 24.2 | Acceptance of new track construction or track renewal | 692 |
| 24.2.1 | General | 692 |
| 24.2.2 | Acceptance following new track construction or track renewal | 692 |
| 24.2.3 | SR ₀ values for new track construction or track renewal | 695 |
| 24.2.4 | SR ₀ values of the geodetic position of the track and other measurements | 697 |
| 24.2.5 | Checklist for acceptance documents | 698 |
| 24.3 | Acceptance of new switch construction and switch renewal | 699 |
| 24.3.1 | General | 699 |
| 24.3.2 | Object of acceptance | 699 |
| 24.3.3 | Acceptance following new switch construction and switch renewal | 699 |
| 24.3.4 | SR ₀ values of the switch geometry | 701 |
| 24.4 | Acceptance of track maintenance | 703 |
| 24.4.1 | General | 703 |
| 24.4.2 | Acceptance of track maintenance | 703 |

| | | |
|-------------|---|------------|
| 24.4.3 | Evaluation of acceptance survey | 704 |
| 24.5 | Acceptance of switch maintenance | 705 |
| 24.5.1 | General | 705 |
| 24.5.2 | Acceptance of switch maintenance | 705 |
| 24.5.3 | SR ₀ values for switch maintenance | 706 |
| 24.6 | Acceptance of welded joints on rails | 707 |
| 24.6.1 | General | 707 |
| 24.6.2 | Principles | 708 |
| 24.6.3 | Tools | 708 |
| 24.6.4 | Acceptance of welded joints on rails | 708 |
| 24.7 | Acceptance of rail processing | 713 |
| 24.7.1 | General | 713 |
| 24.7.2 | Acceptance of rail processing | 713 |
| 24.7.3 | Guideline acceptance values following rail processing | 715 |
| 24.7.4 | Guideline acceptance values following the production of special profiles | 718 |
| 25 | Further developments | 719 |
| 25.1 | General | 719 |
| 25.2 | SUZW 500 – new technology for track renewal in conveyor belt technology, H.F. WIEBE | 719 |
| 25.3 | Ballast bed cleaning machine RM900VB | 723 |
| 25.4 | Mobile maintenance system ROBEL 69.70 | 726 |
| 25.5 | Ballastless track system DW pre-cast concrete track panels as the track support system | 729 |
| 25.5.1 | System description | 730 |
| 25.5.2 | Routing principles | 730 |
| 25.5.3 | Construction implementation | 730 |
| 25.6 | The DURFLEX® superstructure system | 732 |
| 25.6.1 | Characteristics of DURFLEX® | 732 |
| 25.6.2 | Laying procedure (Durflex® installation) | 733 |
| 25.6.3 | Removal procedure and recycling | 735 |

| | | |
|--------------|---|------------|
| 25.7 | Drive-on ballastless track system | 735 |
| 25.7.1 | System description | 735 |
| 25.7.2 | Laying procedure on earthworks (rough construction sequence) | 737 |
| 25.8 | The ZSX twin sleeper – the special pre-stressed concrete sleeper | 737 |
| 25.8.1 | The development objectives of the ZSX twin sleeper | 737 |
| 25.8.2 | Laying procedure | 738 |
| 25.9 | DURMINOR®, the low noise protection wall | 741 |
| 25.10 | New developments in ballastless track system design types | 743 |
| 25.10.1 | New ballastless track system design type | 743 |
| 25.10.2 | ”Naumburger Bauunion“ (NBU) design type | 744 |

Annex

| | |
|----------------------|-----|
| Abbreviations | 746 |
| Units of measurement | 747 |
| Advertisers | 747 |
| Index | 748 |
| Authors | 752 |