Construction of **Sewage Network and Waste Water Treatment Plant (WWTP) in the Municipality of Berane**

Volume 3-1 Employer’s Requirements Section 5. General Specifications

for Civil Works

June 2015

Table of Contents

[1. Introduction 21](#_Toc414436626)

[1.1. Standards and Regulations 21](#_Toc414436627)

[1.2. Scope of Works 21](#_Toc414436628)

[1.3. List of abbreviations 22](#_Toc414436629)

[2. Demolition and Protection of Works 23](#_Toc414436630)

[2.1. General 23](#_Toc414436631)

[2.2. Workmanship 24](#_Toc414436632)

[2.3. Protection of Existing Objects 24](#_Toc414436633)

[2.4. Filling and Sealing of Abandoned Pipelines 25](#_Toc414436634)

[2.5. Disposal of Demolition Materials 25](#_Toc414436635)

[2.6. Refilling and Finishing 25](#_Toc414436636)

[2.7. Permission 25](#_Toc414436637)

[3. Clearing and Grubbing 26](#_Toc414436638)

[3.1. Clearance of Sites 26](#_Toc414436639)

[3.2. Protections 26](#_Toc414436640)

[3.3. Road Furniture 26](#_Toc414436641)

[3.4. Disposals 26](#_Toc414436642)

[3.5. Blasting 26](#_Toc414436643)

[3.6. Notice of Commencement 27](#_Toc414436644)

[4. Earthworks 28](#_Toc414436645)

[4.1. Standards 28](#_Toc414436646)

[4.2. Design, Loading Assumptions 28](#_Toc414436647)

[4.2.1. Site investigations 28](#_Toc414436648)

[4.2.2. Geotechnical report and ground improvement 29](#_Toc414436649)

[4.2.3. Soil replacement 30](#_Toc414436650)

[4.2.4. Admixture stabilization 30](#_Toc414436651)

[4.3. General Instructions 30](#_Toc414436652)

[4.3.1. Excavation Method Statement 30](#_Toc414436653)

[4.3.2. Notice of Commencement 30](#_Toc414436654)

[4.3.3. Traffic requirements 30](#_Toc414436655)

[4.3.4. Earthworks to Lines and Levels 31](#_Toc414436656)

[4.3.5. Stripping of Topsoil 31](#_Toc414436657)

[4.3.6. Relocation of Possible Utilities and Trial holes 31](#_Toc414436658)

[4.3.7. Disposals 32](#_Toc414436659)

[4.4. Excavations 32](#_Toc414436660)

[4.4.1. Extent of Excavations 32](#_Toc414436661)

[4.4.2. Excavation of Unsound Material 32](#_Toc414436662)

[4.4.3. Slips, Falls and Excess Excavations 33](#_Toc414436663)

[4.4.4. Excavation to be Kept Free From Water 33](#_Toc414436664)

[4.4.5. Crossing Watercourses 34](#_Toc414436665)

[4.4.6. Intersections with roads, highways and railroads 34](#_Toc414436666)

[4.4.7. Formation Level 34](#_Toc414436667)

[4.4.8. Inspection by the Engineer 35](#_Toc414436668)

[4.4.9. Disposal of Surplus Excavated Material 35](#_Toc414436669)

[4.4.10. Tests on Ground Water 35](#_Toc414436670)

[4.5. Geotextiles 36](#_Toc414436671)

[4.5.1. Standards and Norms 36](#_Toc414436672)

[4.5.2. Application 36](#_Toc414436673)

[4.5.3. Material Requirements 36](#_Toc414436674)

[4.5.4. Testing 37](#_Toc414436675)

[4.5.5. Execution and Workmanship 37](#_Toc414436676)

[4.6. Filling 38](#_Toc414436677)

[4.6.1. General 38](#_Toc414436678)

[4.6.2. Fill Materials to be provided by the Contractor 39](#_Toc414436679)

[4.6.3. Fill Materials Obtained from the Site Excavations 39](#_Toc414436680)

[4.6.4. Preliminary Tests for Compacted Fill 39](#_Toc414436681)

[4.6.5. Filling not to Endanger Structures 39](#_Toc414436682)

[4.6.6. Back-filling of Excavations for Pipes or Cables 40](#_Toc414436683)

[4.6.7. Stanks to Pipeline with Granular Bedding 40](#_Toc414436684)

[4.6.8. Back-filling of Excavations for Structures 41](#_Toc414436685)

[4.6.9. Required Compaction for Various Fills 41](#_Toc414436686)

[4.6.10. Main Tests and Standards 42](#_Toc414436687)

[4.6.11. Temporary Sheeting and Bracing 42](#_Toc414436688)

[4.6.12. Levelling of Areas 42](#_Toc414436689)

[4.7. Flood Protection 42](#_Toc414436690)

[4.7.1. Earth dikes 42](#_Toc414436691)

[4.7.2. Mortared stone walls and slabs 43](#_Toc414436692)

[5. Roadworks 44](#_Toc414436693)

[5.1. Standards 44](#_Toc414436694)

[5.2. General 44](#_Toc414436695)

[5.3. General Road Layer Structure 44](#_Toc414436696)

[5.3.1. Top or Wearing Course 44](#_Toc414436697)

[5.3.2. Binder Course 44](#_Toc414436698)

[5.3.3. Base courses 45](#_Toc414436699)

[5.3.4. Roads to be reinstated 45](#_Toc414436700)

[5.4. Clearing and Grubbing 45](#_Toc414436701)

[5.5. Earthworks for Roads 45](#_Toc414436702)

[5.6. Filling of Excavations beneath Site Roads and Public Roads 46](#_Toc414436703)

[5.7. Finish and Protection of Sub-Grade 46](#_Toc414436704)

[5.8. Material and Construction of Sub-Base 46](#_Toc414436705)

[5.9. Hydraulically Bound Base Course 47](#_Toc414436706)

[5.10. Temporary Reinstatement of Public Roads 48](#_Toc414436707)

[5.11. Asphalt Pavements 48](#_Toc414436708)

[5.11.1. Bituminous Works 48](#_Toc414436709)

[5.11.2. Weather Limitations 48](#_Toc414436710)

[5.11.3. Preparation 48](#_Toc414436711)

[5.11.4. Transportation 49](#_Toc414436712)

[5.11.5. Placing 49](#_Toc414436713)

[5.11.6. Compaction of Mixtures 49](#_Toc414436714)

[5.12. Concrete Pavements 50](#_Toc414436715)

[5.12.1. General 50](#_Toc414436716)

[5.12.2. Joints 50](#_Toc414436717)

[5.12.3. Dummy Joints 50](#_Toc414436718)

[5.12.4. Expansion Joints 51](#_Toc414436719)

[5.12.5. Pavements with Cobblestones 51](#_Toc414436720)

[5.12.6. Side Walks Pavements 51](#_Toc414436721)

[5.13. Drainage 51](#_Toc414436722)

[5.13.1. Open Drainage Channels 52](#_Toc414436723)

[5.13.2. Rip-Rap 52](#_Toc414436724)

[5.13.3. Filter Fabric 52](#_Toc414436725)

[5.14. Kerb Laying 52](#_Toc414436726)

[5.15. Gravel Roads 53](#_Toc414436727)

[5.16. Road Markings 53](#_Toc414436728)

[5.17. Concrete Bollards 53](#_Toc414436729)

[5.18. Testing 53](#_Toc414436730)

[6. Concrete 54](#_Toc414436731)

[6.1. Standards 54](#_Toc414436732)

[6.2. Design Concrete Requirements 55](#_Toc414436733)

[6.2.1. Concrete Classes 55](#_Toc414436734)

[6.2.2. Crack Control under Working Load 55](#_Toc414436735)

[6.2.3. Minimum Member Thickness 56](#_Toc414436736)

[6.3. Organisation of Concrete Production at the Site 56](#_Toc414436737)

[6.4. Ready Mix Concrete 56](#_Toc414436738)

[6.5. Materials and Testing 56](#_Toc414436739)

[6.5.1. Type of Cement 56](#_Toc414436740)

[6.5.2. Tests of Cement 57](#_Toc414436741)

[6.5.3. Delivery and Storage of Cement 57](#_Toc414436742)

[6.5.4. Cement Measured by Weight 58](#_Toc414436743)

[6.5.5. Rejection of Cement 58](#_Toc414436744)

[6.5.6. Quality of Water 58](#_Toc414436745)

[6.5.7. Fine and Coarse Aggregates 58](#_Toc414436746)

[6.5.8. Grading of Aggregates 59](#_Toc414436747)

[6.5.9. Storage of Aggregates 59](#_Toc414436748)

[6.5.10. Tests on Aggregates 59](#_Toc414436749)

[6.5.11. Admixtures and Additions 60](#_Toc414436750)

[6.5.12. Delivery of Samples 60](#_Toc414436751)

[6.6. Concrete Mixing and Testing 60](#_Toc414436752)

[6.6.1. Proportions of Materials 60](#_Toc414436753)

[6.6.2. Water-Cement Ratio and Compressive Strength 60](#_Toc414436754)

[6.6.3. Limits of Salt Contents 61](#_Toc414436755)

[6.6.4. Consistency 61](#_Toc414436756)

[6.6.5. Concrete Mix Design 61](#_Toc414436757)

[6.6.6. Preliminary Mix Tests 61](#_Toc414436758)

[6.6.7. Trial Mixes of Concrete 61](#_Toc414436759)

[6.6.8. Concrete Testing 62](#_Toc414436760)

[6.6.9. Compliance Requirements for Concrete 63](#_Toc414436761)

[6.6.10. Mix not Approved 63](#_Toc414436762)

[6.6.11. Additional Testing of Concrete 63](#_Toc414436763)

[6.6.12. Water Content 64](#_Toc414436764)

[6.6.13. Weigh Batching and Mixing 64](#_Toc414436765)

[6.6.14. Ready-Mix Concrete 65](#_Toc414436766)

[6.6.15. Sand-Cement Mortar 66](#_Toc414436767)

[6.7. Placing and Concrete Compaction 66](#_Toc414436768)

[6.7.1. Preparatory Work 66](#_Toc414436769)

[6.7.2. Depositing in Work 67](#_Toc414436770)

[6.7.3. Depositing in Layers 67](#_Toc414436771)

[6.7.4. Concrete Placed in Water 68](#_Toc414436772)

[6.7.5. Concreting in Hot Weather 68](#_Toc414436773)

[6.7.6. Concreting in Cold Weather 68](#_Toc414436774)

[6.7.7. Concreting in Unfavourable Weather 69](#_Toc414436775)

[6.7.8. Test Blocks 70](#_Toc414436776)

[6.7.9. Compaction of Concrete 71](#_Toc414436777)

[6.7.10. Placing Concrete on Previously Executed Work 72](#_Toc414436778)

[6.7.11. Protection and Curing of Concrete 72](#_Toc414436779)

[6.7.12. Record of Concreting 72](#_Toc414436780)

[6.7.13. Faulty Work 72](#_Toc414436781)

[6.7.14. Blinding Concrete (Sub-base) 73](#_Toc414436782)

[6.7.15. Loading of Concrete Structures 73](#_Toc414436783)

[6.8. Joints 73](#_Toc414436784)

[6.8.1. Construction Joints 73](#_Toc414436785)

[6.8.2. Contraction joints 74](#_Toc414436786)

[6.8.3. Expansions Joints 74](#_Toc414436787)

[6.8.4. Metal Components Cast in Concrete 76](#_Toc414436788)

[6.9. Testing of tanks 77](#_Toc414436789)

[7. Shuttering and Concrete Finishes 78](#_Toc414436790)

[7.1. Standards 78](#_Toc414436791)

[7.1.1. Formwork 78](#_Toc414436792)

[7.1.2. Drawings and Calculations 78](#_Toc414436793)

[7.1.3. Materials for Shuttering 78](#_Toc414436794)

[7.1.4. Fixing of Shuttering 79](#_Toc414436795)

[7.1.5. Back Shuttering 79](#_Toc414436796)

[7.1.6. Form Ties 79](#_Toc414436797)

[7.1.7. Coating to Prevent Adhesion 79](#_Toc414436798)

[7.1.8. Access Holes 79](#_Toc414436799)

[7.1.9. Cleaning and Re-Using of Shuttering 79](#_Toc414436800)

[7.1.10. Removal of Shutters 80](#_Toc414436801)

[7.1.11. Finish to Concrete Surfaces 80](#_Toc414436802)

[7.1.12. Dimension and Surfaces of In-Situ Concrete 81](#_Toc414436803)

[8. Dry-Pack Mortar 83](#_Toc414436804)

[8.1. Dry-Pack Mortar for Concrete Structures not in Contact with Water or Sludge 83](#_Toc414436805)

[8.2. Dry-Pack Mortar for Concrete Structures in Contact with Water or Sludge 83](#_Toc414436806)

[9. Remedial Treatment of Concrete Surfaces 84](#_Toc414436807)

[9.1. Repair Workmanship 84](#_Toc414436808)

[10. Concrete Injection 85](#_Toc414436809)

[10.1. Equipment 85](#_Toc414436810)

[10.2. Injection Personnel Qualifications 85](#_Toc414436811)

[10.3. Crack Surface Preparation and Cleaning Requirements 85](#_Toc414436812)

[10.4. Sealing Cracks for Epoxy Injection 85](#_Toc414436813)

[10.5. Epoxy Injection 86](#_Toc414436814)

[10.6. Cleaning After Epoxy Injection 86](#_Toc414436815)

[10.7. Acceptance 86](#_Toc414436816)

[11. Steel Reinforcement 87](#_Toc414436817)

[11.1. Design Requirements 87](#_Toc414436818)

[11.2. Types and Quality and Storage of Reinforcement 87](#_Toc414436819)

[11.3. Prestressing Steel 87](#_Toc414436820)

[11.4. Bending and Cutting Schedules 88](#_Toc414436821)

[11.5. Protection and Cleaning 88](#_Toc414436822)

[11.6. Bending of Bars 89](#_Toc414436823)

[11.7. Cutting of Wire Fabrics 89](#_Toc414436824)

[11.8. Lapping of Bars and Wire Fabrics 89](#_Toc414436825)

[11.9. Fixing of Reinforcement 89](#_Toc414436826)

[11.10. Thickness of Cover 90](#_Toc414436827)

[11.11. Tolerances 90](#_Toc414436828)

[11.12. Approval before Concreting 90](#_Toc414436829)

[12. Pre-stressed Concrete 91](#_Toc414436830)

[12.1. Sustainability of Pre-stressed Concrete Structures 91](#_Toc414436831)

[12.2. Tendons 91](#_Toc414436832)

[12.2.1. Tendon Fabrication and Supply 91](#_Toc414436833)

[12.2.2. Storage and Cleaning 91](#_Toc414436834)

[12.2.3. Testing Requirements for Tendons 92](#_Toc414436835)

[12.2.4. Corrosion Protection of unbounded Tendons 92](#_Toc414436836)

[12.3. Anchorage 93](#_Toc414436837)

[12.3.1. Types of Anchorage 93](#_Toc414436838)

[12.3.2. Anchorage for Bar Tendons 93](#_Toc414436839)

[12.3.3. Anchorage for Multiple Strand Tendons 93](#_Toc414436840)

[12.3.4. Anchorage for Multiple Wire Tendons 93](#_Toc414436841)

[12.3.5. Requirements 94](#_Toc414436842)

[12.3.6. Anchorage Reinforcement 94](#_Toc414436843)

[12.4. Sheathing 94](#_Toc414436844)

[12.4.1. Specific Requirements 94](#_Toc414436845)

[12.5. Installation of Pre-Tensioning Systems 95](#_Toc414436846)

[12.5.1. Pre-Tensioning Anchorages Installation 95](#_Toc414436847)

[12.5.2. Pre-Tensioning Tendon Installation 95](#_Toc414436848)

[12.6. Installation of Post-Tensioning Systems 96](#_Toc414436849)

[12.6.1. Grout Holes Installation 96](#_Toc414436850)

[12.6.2. Tendon Installation 96](#_Toc414436851)

[12.7. Stressing Equipment 96](#_Toc414436852)

[12.8. Stressing Records 97](#_Toc414436853)

[12.9. Pre-Tensioning Stressing 98](#_Toc414436854)

[12.9.1. Pre-Stressing 98](#_Toc414436855)

[12.9.2. Single Straight Strand Stressing 98](#_Toc414436856)

[12.9.3. Multiple Straight Strand Stressing 98](#_Toc414436857)

[12.9.4. Draped Strand Stressing 99](#_Toc414436858)

[12.9.5. Wire Breakage 99](#_Toc414436859)

[12.9.6. Strand Chucks and Splice Chucks 99](#_Toc414436860)

[12.9.7. Cleanliness of Prestressing Steel 100](#_Toc414436861)

[12.10. Detensioning 100](#_Toc414436862)

[12.10.1. Method of Stress Transfer 100](#_Toc414436863)

[12.10.2. Trimming Strands 101](#_Toc414436864)

[12.11. Post-Tensioning Stressing 101](#_Toc414436865)

[12.11.1. Stressing Procedure 101](#_Toc414436866)

[12.11.2. Tensioning with one Jack 102](#_Toc414436867)

[12.12. Grouting 102](#_Toc414436868)

[12.12.1. Preparation of the Duct before Grouting 102](#_Toc414436869)

[12.12.2. Grout Materials and Properties 102](#_Toc414436870)

[12.12.3. Mixing and Pumping Equipment 103](#_Toc414436871)

[12.12.4. Grouting 103](#_Toc414436872)

[12.12.5. Trimming 103](#_Toc414436873)

[13. Precast Concrete Structures Units 104](#_Toc414436874)

[13.1. Fabrication 104](#_Toc414436875)

[13.2. Concrete Quality and Tests on Concrete 104](#_Toc414436876)

[13.3. Concrete Quality and Tests on Concrete 104](#_Toc414436877)

[13.4. Cast-In Parts 104](#_Toc414436878)

[13.5. Marking of Precast Structures 104](#_Toc414436879)

[13.6. Lifting, Handling, Stacking 105](#_Toc414436880)

[13.7. Transport, Storage and Erection 105](#_Toc414436881)

[13.8. Installation of Precast Concrete 105](#_Toc414436882)

[13.9. Manufacturing in a Factory 105](#_Toc414436883)

[13.10. Work Programme and Method Statement 105](#_Toc414436884)

[14. Connection to Concrete Structures 107](#_Toc414436885)

[14.1. Building-In Pipes and Other Items 107](#_Toc414436886)

[14.2. Cutting or Displacement of Reinforcement 107](#_Toc414436887)

[14.3. Cleaning 108](#_Toc414436888)

[14.4. Grouting in Narrow Spaces 108](#_Toc414436889)

[14.5. Joint between Old and New Concrete 108](#_Toc414436890)

[14.6. Grouting under Handrails 108](#_Toc414436891)

[15. Coatings on Concrete Surfaces 109](#_Toc414436892)

[15.1. Preparation of Surface 109](#_Toc414436893)

[15.2. Application 109](#_Toc414436894)

[15.3. Coating Underside of Structures 110](#_Toc414436895)

[16. Pipelines 111](#_Toc414436896)

[16.1. Standards 111](#_Toc414436897)

[16.2. Static Calculations for Pipelines 111](#_Toc414436898)

[16.3. Pipe Laying in Trenches 112](#_Toc414436899)

[16.3.1. Trench-less Pipe Laying Methods 113](#_Toc414436900)

[16.3.2. Quality Control 113](#_Toc414436901)

[16.3.3. Boring Path Report 113](#_Toc414436902)

[16.3.4. Boring Path Drawings 114](#_Toc414436903)

[16.4. Directional Boring 114](#_Toc414436904)

[16.4.1. Drilling Fluids & Reamer Hole Diameter 114](#_Toc414436905)

[16.4.2. Testing 115](#_Toc414436906)

[16.4.3. Locating and Tracking 115](#_Toc414436907)

[16.4.4. Equipment Requirements 116](#_Toc414436908)

[16.4.5. Obstructions 116](#_Toc414436909)

[16.5. Building Pipes through Structures 116](#_Toc414436910)

[16.6. Connecting to Existing Pipes 117](#_Toc414436911)

[16.7. Thrust Blocks 117](#_Toc414436912)

[16.8. Securing against Uplift 117](#_Toc414436913)

[16.9. Concrete Protection to Pipelines 117](#_Toc414436914)

[16.10. Flange Connections 118](#_Toc414436915)

[16.10.1. Standards 118](#_Toc414436916)

[16.10.2. Fastenings 118](#_Toc414436917)

[16.11. Pipe Thermal Insulation 118](#_Toc414436918)

[16.11.1. Standards 119](#_Toc414436919)

[16.11.2. Insulating Material 119](#_Toc414436920)

[16.12. Jackets 119](#_Toc414436921)

[16.12.1. Aluminium Jackets 119](#_Toc414436922)

[16.12.2. PVC Jackets 120](#_Toc414436923)

[16.12.3. PEHD Jackets 120](#_Toc414436924)

[16.13. Galvanised Folded Spiral Pipe Jackets 120](#_Toc414436925)

[16.13.1. Vapour Retarder Coating 120](#_Toc414436926)

[16.13.2. Installation General 120](#_Toc414436927)

[16.13.3. Installation of Flexible Cellular Insulation 120](#_Toc414436928)

[16.13.4. Factory Pre-insulated Pipe Systems 121](#_Toc414436929)

[16.13.5. Pipe Heating Cables 121](#_Toc414436930)

[16.14. Fittings, Valves and Accessories 121](#_Toc414436931)

[16.14.1. Tees and Wyes 121](#_Toc414436932)

[16.14.2. Dismantling Joints 121](#_Toc414436933)

[16.14.3. Anchoring Sleeves 122](#_Toc414436934)

[16.15. Testing of Pipelines 122](#_Toc414436935)

[16.15.1. Testing of Gravity Pipelines 123](#_Toc414436936)

[16.15.2. Testing of Pressure Pipelines 123](#_Toc414436937)

[16.16. Inspection of Pipelines 124](#_Toc414436938)

[16.16.1. Pipe Pigging 124](#_Toc414436939)

[16.16.2. Pipe TV-Inspection 124](#_Toc414436940)

[16.17. Cleansing and Disinfection of the Pipelines 124](#_Toc414436941)

[16.17.1. Preliminary Flushing 124](#_Toc414436942)

[16.17.2. Cleansing 124](#_Toc414436943)

[16.17.3. Disinfecting of Water Supply Pipes 125](#_Toc414436944)

[16.17.4. Bacteriological Testing of Water Supply Pipes 125](#_Toc414436945)

[16.18. Concrete Pipes, Pipe-Laying and Testing 125](#_Toc414436946)

[16.18.1. Standards 125](#_Toc414436947)

[16.18.2. Classification 126](#_Toc414436948)

[16.18.3. Quality and Testing of Materials 126](#_Toc414436949)

[16.19. Supply of Concrete Pipes 126](#_Toc414436950)

[16.19.1. Non-Reinforced Concrete Pipes 126](#_Toc414436951)

[16.19.2. Reinforced Concrete Pipes 127](#_Toc414436952)

[16.19.3. Prestressed Concrete Pipes 127](#_Toc414436953)

[16.19.4. Spigot and Bell Rings Outside Corrosion Protection 127](#_Toc414436954)

[16.19.5. Spigot And Bell Rings Inside Corrosion Protection 127](#_Toc414436955)

[16.20. Joints 128](#_Toc414436956)

[16.20.1. Types of Joints 128](#_Toc414436957)

[16.20.2. Sealing of Joints 128](#_Toc414436958)

[16.21. Manufacturer’s Tests 128](#_Toc414436959)

[16.21.1. Water-Tightness 128](#_Toc414436960)

[16.21.2. Strength of the Pipe 128](#_Toc414436961)

[16.21.3. Transport and Storage 128](#_Toc414436962)

[16.21.4. Rejection of Pipes 128](#_Toc414436963)

[16.21.5. Repair of Pipe Imperfections 129](#_Toc414436964)

[16.21.6. Preparation of Surfaces to be repaired 129](#_Toc414436965)

[16.21.7. Placement of Repair Mortar 129](#_Toc414436966)

[16.22. Laying of Concrete Pipes 129](#_Toc414436967)

[16.22.1. Excavation and Backfilling 129](#_Toc414436968)

[16.22.2. Granular Material for Bedding to Pipelines 129](#_Toc414436969)

[16.22.3. Laying of Pipes 129](#_Toc414436970)

[16.22.4. Pipe Jointing 130](#_Toc414436971)

[16.23. Ductile Iron and Steel Pipe Lining and Coating 130](#_Toc414436972)

[16.23.1. Standards 130](#_Toc414436973)

[16.23.2. Requirements 131](#_Toc414436974)

[16.23.3. Pipe Inspection 132](#_Toc414436975)

[16.23.4. Pipe Surface Contamination and Removal 132](#_Toc414436976)

[16.23.5. Coating Systems / Material 132](#_Toc414436977)

[16.23.6. FBE / FBPE or FBPP Coating 133](#_Toc414436978)

[16.23.7. Three-Layer PE / PP Coating 133](#_Toc414436979)

[16.23.8. CTE Coating 133](#_Toc414436980)

[16.23.9. Zinc and Bituminous Coating 133](#_Toc414436981)

[16.23.10. PU Spray Coat for Field Joints 133](#_Toc414436982)

[16.23.11. Heat Shrinkable Sleeve for Field Joints 134](#_Toc414436983)

[16.23.12. Mastic 134](#_Toc414436984)

[16.23.13. Reinforced Tape Wraps for Field Joints 134](#_Toc414436985)

[16.23.14. Solids Rigid Polyurethane Internal Lining 134](#_Toc414436986)

[16.23.15. Cement Mortar Internal Lining 135](#_Toc414436987)

[16.23.16. Surface Preparation 135](#_Toc414436988)

[16.24. Field Coating Application 135](#_Toc414436989)

[16.24.1. Priming 135](#_Toc414436990)

[16.24.2. CTE Application 136](#_Toc414436991)

[16.24.3. Application of Tape Inner Wrap 136](#_Toc414436992)

[16.24.4. Application of Tape Outer Wrap 136](#_Toc414436993)

[16.24.5. PU Spray Coat for Field Joints 136](#_Toc414436994)

[16.24.6. Heat Shrinkable Sleeve for Field Joints 136](#_Toc414436995)

[16.24.7. Hot Mastic for Field Joints 137](#_Toc414436996)

[16.24.8. Tape Coating Field Joints, Fittings, Connections 137](#_Toc414436997)

[16.25. Inspection and Testing 137](#_Toc414436998)

[16.25.1. Coating Thickness Measurements 138](#_Toc414436999)

[16.25.2. Electrical Inspection 138](#_Toc414437000)

[16.26. Repair Procedures 138](#_Toc414437001)

[16.26.1. FBE Coating 138](#_Toc414437002)

[16.26.2. Tape Systems 138](#_Toc414437003)

[16.26.3. Cement Linings 138](#_Toc414437004)

[16.26.4. Coated Pipe Handling, Storage and Loading Requirements 139](#_Toc414437005)

[16.27. Ductile Iron Pipes 139](#_Toc414437006)

[16.27.1. Standards 139](#_Toc414437007)

[16.27.2. Material 139](#_Toc414437008)

[16.27.3. Maximum Working Pressure and Internal Pressure Proof Test 140](#_Toc414437009)

[16.28. Joints 140](#_Toc414437010)

[16.28.1. Socket and Spigot Pipes 140](#_Toc414437011)

[16.28.2. Flanged Pipes 140](#_Toc414437012)

[16.28.3. Fittings 141](#_Toc414437013)

[16.29. Coating 141](#_Toc414437014)

[16.29.1. Pipes for Water Supply 141](#_Toc414437015)

[16.29.2. Pipes for Pumped Sewage 141](#_Toc414437016)

[16.29.3. Bends and Tees 141](#_Toc414437017)

[16.30. Transport and Storage 141](#_Toc414437018)

[16.31. Re-Rounding and Cutting of Pipes 142](#_Toc414437019)

[16.32. Laying and Jointing 142](#_Toc414437020)

[16.33. Steel Pipes, Pipe Laying and Testing 142](#_Toc414437021)

[16.33.1. Standards 142](#_Toc414437022)

[16.33.2. Materials and Dimensions 145](#_Toc414437023)

[16.33.3. Sampling, Inspections and Tests 145](#_Toc414437024)

[16.33.4. Marking, Tolerance Class and Certification 146](#_Toc414437025)

[16.33.5. Transport, Storage and Stringing of Pipes 147](#_Toc414437026)

[16.33.6. Pipe Laying 147](#_Toc414437027)

[16.33.7. Welding of Pipelines 147](#_Toc414437028)

[16.33.8. Materials 148](#_Toc414437029)

[16.33.9. Welding Processes 148](#_Toc414437030)

[16.33.10. Welding Procedure Qualification 148](#_Toc414437031)

[16.33.11. Qualification of Welders and Welding Operations 148](#_Toc414437032)

[16.33.12. Welding Preparation 149](#_Toc414437033)

[16.33.13. Weld Pointing 149](#_Toc414437034)

[16.33.14. Welding Workmanship 149](#_Toc414437035)

[16.33.15. Cleaning after Welding 149](#_Toc414437036)

[16.33.16. Post Weld Heat Treatment (PWHT) 150](#_Toc414437037)

[16.33.17. Identification of Weld Seams 150](#_Toc414437038)

[16.33.18. Closing of Pipe Ends 150](#_Toc414437039)

[16.33.19. Welding Inspection 150](#_Toc414437040)

[16.33.20. Extent of Examination 150](#_Toc414437041)

[16.33.21. Acceptance Criteria 151](#_Toc414437042)

[16.33.22. Production Testing 151](#_Toc414437043)

[16.33.23. Other Jointing Methods 152](#_Toc414437044)

[16.34. Galvanised Steel Pipes 152](#_Toc414437045)

[16.34.1. Joints 152](#_Toc414437046)

[16.34.2. Galvanising 152](#_Toc414437047)

[16.35. Stainless Steel Pipes 152](#_Toc414437048)

[16.35.1. Materials and Dimensions 153](#_Toc414437049)

[16.35.2. Welding 153](#_Toc414437050)

[16.35.3. Flanges 153](#_Toc414437051)

[16.36. Plastic Pipes 154](#_Toc414437052)

[16.36.1. PVC Pipes 154](#_Toc414437053)

[16.36.2. PE-HD Pipes 155](#_Toc414437054)

[16.36.3. Welding 155](#_Toc414437055)

[16.36.4. Pipes 156](#_Toc414437056)

[16.36.5. Laying Plastic Pipes 156](#_Toc414437057)

[17. Steelwork 158](#_Toc414437058)

[17.1. General 160](#_Toc414437059)

[17.2. Quality and Testing of Materials 160](#_Toc414437060)

[17.3. Submissions by the Contractor 161](#_Toc414437061)

[17.4. Drawings 161](#_Toc414437062)

[17.5. Calculations 161](#_Toc414437063)

[17.6. Manufacturing and Workmanship 162](#_Toc414437064)

[17.6.1. Fabrication Tolerances 162](#_Toc414437065)

[17.6.2. Dissimilar Metals 162](#_Toc414437066)

[17.6.3. Preparatory Operations 162](#_Toc414437067)

[17.6.4. Welding 163](#_Toc414437068)

[17.6.5. Bolted Joints 163](#_Toc414437069)

[17.6.6. Bolted Parts 164](#_Toc414437070)

[17.6.7. Installation 164](#_Toc414437071)

[17.6.8. Inspection 164](#_Toc414437072)

[17.6.9. Painting 165](#_Toc414437073)

[17.6.10. Standards 165](#_Toc414437074)

[17.6.11. Uncoated Surfaces 165](#_Toc414437075)

[17.6.12. Local Conditions 166](#_Toc414437076)

[17.6.13. Colour Coding and Final Appearance 166](#_Toc414437077)

[17.6.14. Coatings in Contact with Potable Water 166](#_Toc414437078)

[17.6.15. Trial Areas and Sample Pieces 166](#_Toc414437079)

[17.6.16. Precautions 166](#_Toc414437080)

[17.6.17. Equipment 167](#_Toc414437081)

[17.6.18. Paint 167](#_Toc414437082)

[17.6.19. Preparation 167](#_Toc414437083)

[17.6.20. Painting Conditions 168](#_Toc414437084)

[17.6.21. Workmanship 168](#_Toc414437085)

[17.6.22. Paint Thickness and Measurement 169](#_Toc414437086)

[17.6.23. Tolerances 169](#_Toc414437087)

[17.6.24. Painting and Protection of Bolted Connections 170](#_Toc414437088)

[17.6.25. Copper and Brass 170](#_Toc414437089)

[17.6.26. Repair of Damaged Work 170](#_Toc414437090)

[17.6.27. Waste 170](#_Toc414437091)

[17.6.28. Galvanising 170](#_Toc414437092)

[17.7. Delivery and Assembly 171](#_Toc414437093)

[17.7.1. Test Assemblies 171](#_Toc414437094)

[17.7.2. Packing and Marking 171](#_Toc414437095)

[17.7.3. Storage at Site 171](#_Toc414437096)

[17.8. Particular Steelworks 171](#_Toc414437097)

[17.8.1. Manhole and Access Covers and Frames 171](#_Toc414437098)

[17.8.2. Surface Boxes 172](#_Toc414437099)

[17.8.3. Open Steel Flooring 172](#_Toc414437100)

[17.8.4. Chequer Plates 172](#_Toc414437101)

[17.8.5. Steel Staircases 172](#_Toc414437102)

[17.8.6. Step Irons 173](#_Toc414437103)

[17.8.7. Steel Ladders 173](#_Toc414437104)

[17.8.8. Handrail 173](#_Toc414437105)

[17.9. Steel Tanks 174](#_Toc414437106)

[17.9.1. Standards 174](#_Toc414437107)

[17.9.2. General 174](#_Toc414437108)

[17.9.3. Folded Joint Tanks 176](#_Toc414437109)

[17.9.4. Spiral Band Tanks with Folded Joints 176](#_Toc414437110)

[17.9.5. Steel Protection Covers for Membrane Gas Tanks 177](#_Toc414437111)

[17.9.6. Membrane Surge Tanks 177](#_Toc414437112)

[17.9.7. LPG Storage Tanks 177](#_Toc414437113)

[17.9.8. Gasoline Storage Tanks 177](#_Toc414437114)

[17.9.9. Fuel Oil Storage Tanks 177](#_Toc414437115)

[17.9.10. Lube Oil Storage Tanks 178](#_Toc414437116)

[17.9.11. Steel Chemical Tanks 178](#_Toc414437117)

[17.9.12. Condensate Tanks 179](#_Toc414437118)

[17.9.13. Expansion Tanks 179](#_Toc414437119)

[17.10. Structural Steelwork 179](#_Toc414437120)

[18. Concrete Pile Foundations 180](#_Toc414437121)

[18.1. Standards 180](#_Toc414437122)

[18.2. General 180](#_Toc414437123)

[18.3. Types of Piles 180](#_Toc414437124)

[18.4. Design of Piles 180](#_Toc414437125)

[18.5. Preliminary Test Piles 181](#_Toc414437126)

[18.6. Lengths and Tolerances 182](#_Toc414437127)

[18.7. Sequence for Constructions 182](#_Toc414437128)

[18.8. Handling of Precast Piles 182](#_Toc414437129)

[18.9. Driving Piles 183](#_Toc414437130)

[18.10. Repair and Lengthening of Piles 184](#_Toc414437131)

[18.11. Reinforcement 184](#_Toc414437132)

[18.12. Records 185](#_Toc414437133)

[18.13. Precast Reinforced Concrete Piles 185](#_Toc414437134)

[18.14. Cast-In-Situ Piles 185](#_Toc414437135)

[18.14.1. Driven or Bored Cast-In-Situ-Piles 185](#_Toc414437136)

[18.14.2. Casing for Cast-In-Situ Piles 186](#_Toc414437137)

[18.14.3. Concrete Cast-In-Situ Piles 186](#_Toc414437138)

[18.15. Pile Load Tests 186](#_Toc414437139)

[18.15.1. Static Load Tests 187](#_Toc414437140)

[18.15.2. Trial Piles 187](#_Toc414437141)

[18.15.3. Working Piles 187](#_Toc414437142)

[18.15.4. Dynamic Load Tests 187](#_Toc414437143)

[18.15.5. Dynamic Load Test Procedure 188](#_Toc414437144)

[18.15.6. Dynamic Load Test Procedure on Driven Piles 188](#_Toc414437145)

[18.15.7. Dynamic Load Test Procedure on Bored Piles 189](#_Toc414437146)

[18.15.8. Load Test Report 189](#_Toc414437147)

[18.16. Piles in Compression 190](#_Toc414437148)

[18.16.1. Ultimate Bearing Resistance from Static Pile Load Tests 190](#_Toc414437149)

[18.16.2. Ultimate Bearing Resistance from Pile Driving Formulae 191](#_Toc414437150)

[18.16.3. Ultimate Bearing Resistance from Dynamic Load Tests 191](#_Toc414437151)

[18.17. Piles in Tension 192](#_Toc414437152)

[18.18. Supervision of Construction 192](#_Toc414437153)

[18.19. Ground Treatment 193](#_Toc414437154)

[18.20. Permanent Steel (Sheet) Piles 193](#_Toc414437155)

[18.20.1. Standards 193](#_Toc414437156)

[18.20.2. General 194](#_Toc414437157)

[18.20.3. Material Quality 194](#_Toc414437158)

[18.21. Cutting and Welding 194](#_Toc414437159)

[18.21.1. Cutting Sheet Piles 194](#_Toc414437160)

[19. Retaining Walls 196](#_Toc414437161)

[19.1. Design 196](#_Toc414437162)

[19.2. Profiles 196](#_Toc414437163)

[19.3. Tolerances 196](#_Toc414437164)

[19.4. Coating 197](#_Toc414437165)

[19.5. Capping 197](#_Toc414437166)

[20. Ground Anchors 198](#_Toc414437167)

[20.1. Working Drawings 198](#_Toc414437168)

[20.2. Tendon Bond Length Encapsulations 198](#_Toc414437169)

[20.3. Heat Shrinkable Sleeves 198](#_Toc414437170)

[20.4. Heath 198](#_Toc414437171)

[20.5. Bondbreaker 199](#_Toc414437172)

[20.6. Corrosion Inhibiting Compound 199](#_Toc414437173)

[20.7. Grout Tubes 199](#_Toc414437174)

[20.8. Drilling 199](#_Toc414437175)

[20.9. Tendon Insertion 199](#_Toc414437176)

[20.10. Grouting 199](#_Toc414437177)

[20.11. Anchorage Installation 200](#_Toc414437178)

[20.12. Corrosion Protection 200](#_Toc414437179)

[20.13. Testing - General 201](#_Toc414437180)

[20.13.1. Performance Test Procedures 202](#_Toc414437181)

[20.13.2. Proof Test Procedures 202](#_Toc414437182)

[20.13.3. Acceptance Criteria 203](#_Toc414437183)

[21. Steel Pile Foundations 205](#_Toc414437184)

[21.1. Profiles 205](#_Toc414437185)

[21.2. Tolerances 205](#_Toc414437186)

[21.3. Design, Testing, Driving 205](#_Toc414437187)

[21.4. Repair and Lengthening 205](#_Toc414437188)

[21.5. Piling 205](#_Toc414437189)

[21.5.1. Method Statement 205](#_Toc414437190)

[21.5.2. Handling 205](#_Toc414437191)

[21.5.3. Pitching & Driving 206](#_Toc414437192)

[21.5.4. Driving Tolerances 207](#_Toc414437193)

[21.5.5. Driving Records 207](#_Toc414437194)

[22. Fences and Landscaping 208](#_Toc414437195)

[22.1. Fence and Gates 208](#_Toc414437196)

[22.1.1. Fences 208](#_Toc414437197)

[22.1.2. Gates 208](#_Toc414437198)

[22.2. Landscaping 209](#_Toc414437199)

[22.2.1. Preparation of Ground 209](#_Toc414437200)

[22.2.2. Top Soil 209](#_Toc414437201)

[22.2.3. Time for Planting 209](#_Toc414437202)

[22.2.4. Leaching 210](#_Toc414437203)

[22.2.5. Top Soil Dressing 210](#_Toc414437204)

[22.2.6. Supply and Planting of Trees and Shrubs 210](#_Toc414437205)

[22.2.7. Support for Climbing Plants 211](#_Toc414437206)

[22.2.8. Supply and Planting of Grasses 211](#_Toc414437207)

[22.2.9. Irrigation 211](#_Toc414437208)

[22.2.10. Maintenance 211](#_Toc414437209)

[22.2.11. Replacement 211](#_Toc414437210)

[23. Building Works 212](#_Toc414437211)

[23.1. General 212](#_Toc414437212)

[23.1.1. Scope of Works 212](#_Toc414437213)

[23.1.2. Standards 212](#_Toc414437214)

[23.1.3. Approval of Materials and Workmanship 212](#_Toc414437215)

[23.2. Masonry 212](#_Toc414437216)

[23.2.1. Bricks 212](#_Toc414437217)

[23.2.2. Mortar 212](#_Toc414437218)

[23.2.3. Workmanship 213](#_Toc414437219)

[23.2.4. Miscellaneous 213](#_Toc414437220)

[23.2.5. Cleaning 213](#_Toc414437221)

[23.3. Plastering 214](#_Toc414437222)

[23.3.1. Mortar 214](#_Toc414437223)

[23.3.2. Workmanship 214](#_Toc414437224)

[23.4. Floor Screed 215](#_Toc414437225)

[23.5. Internal Flooring 215](#_Toc414437226)

[23.5.1. Paving 215](#_Toc414437227)

[23.5.2. Computer Room Flooring 216](#_Toc414437228)

[23.5.3. PVC Flooring 216](#_Toc414437229)

[23.5.4. Carpeting 217](#_Toc414437230)

[23.5.5. Preparation of Surfaces 217](#_Toc414437231)

[23.5.6. Workmanship 217](#_Toc414437232)

[23.5.7. Protection 217](#_Toc414437233)

[23.6. Internal Wall-Tiling 217](#_Toc414437234)

[23.6.1. Materials 217](#_Toc414437235)

[23.6.2. Placing of Tiles 218](#_Toc414437236)

[23.7. Wall Painting 218](#_Toc414437237)

[23.8. Roof Construction 218](#_Toc414437238)

[23.8.1. Timber Truss Works 219](#_Toc414437239)

[23.8.2. Roof Thermal Insulation 219](#_Toc414437240)

[23.8.3. Roof Cover 219](#_Toc414437241)

[23.8.4. Flashings and Gutters 220](#_Toc414437242)

[23.8.5. Vent Pipes 220](#_Toc414437243)

[23.8.6. Roofing Tiles 220](#_Toc414437244)

[23.8.7. Rainwater Drainage 220](#_Toc414437245)

[23.9. Doors and Windows General 220](#_Toc414437246)

[23.9.1. Construction 220](#_Toc414437247)

[23.9.2. Hardware 221](#_Toc414437248)

[23.9.3. Frames 221](#_Toc414437249)

[23.9.4. Jointing, Pointing, Sealants 221](#_Toc414437250)

[23.9.5. Doors 222](#_Toc414437251)

[23.9.6. Doors Hardware 222](#_Toc414437252)

[23.9.7. Door Bottoms 222](#_Toc414437253)

[23.9.8. Steel Door Frames 222](#_Toc414437254)

[23.9.9. Timber Door Leaves 223](#_Toc414437255)

[23.9.10. Steel Doors Leaves 223](#_Toc414437256)

[23.9.11. Aluminium Doors 223](#_Toc414437257)

[23.9.12. Windows 224](#_Toc414437258)

[23.9.13. Hardware 224](#_Toc414437259)

[23.9.14. Aluminium Windows 224](#_Toc414437260)

[23.9.15. PVC Windows 224](#_Toc414437261)

[23.10. Suspended Ceilings 224](#_Toc414437262)

[23.11. Sanitary Systems 225](#_Toc414437263)

[23.11.1. General 226](#_Toc414437264)

[23.11.2. Pipes and Fittings 226](#_Toc414437265)

[23.11.3. Joints and Connections 226](#_Toc414437266)

[23.11.4. Unions 226](#_Toc414437267)

[23.11.5. Hangers, Spacing and Supports 226](#_Toc414437268)

[23.11.6. Manholes and Inspection Pits 226](#_Toc414437269)

[23.11.7. Sleeves 227](#_Toc414437270)

[23.11.8. Protection and Cleaning 227](#_Toc414437271)

[23.11.9. Floor Drains 227](#_Toc414437272)

[23.11.10. Installation of Pipes 227](#_Toc414437273)

[23.11.11. Inspection, Storage and Connections 227](#_Toc414437274)

[23.11.12. Cold Water Pipes and Valves 227](#_Toc414437275)

[23.11.13. Hot Water Boilers 228](#_Toc414437276)

[23.11.14. European Water Closet 228](#_Toc414437277)

[23.11.15. Squatting (Asian) Water Closet 229](#_Toc414437278)

[23.11.16. Bowl Urinals 229](#_Toc414437279)

[23.11.17. Wash Basins 229](#_Toc414437280)

[23.11.18. Showers 229](#_Toc414437281)

[23.11.19. Sinks 229](#_Toc414437282)

[23.11.20. Testing of Sanitary System 229](#_Toc414437283)

[23.11.21. Pressure Tests of Drainage 230](#_Toc414437284)

[23.11.22. Pressure Tests of Water Supply Pipes 230](#_Toc414437285)

[23.11.23. Flow Test 230](#_Toc414437286)

[23.12. Home Appliance and Furniture 230](#_Toc414437287)

[23.12.1. Air Conditioner 230](#_Toc414437288)

[23.12.2. Refrigerator 231](#_Toc414437289)

[23.13. Piping for House Installations 231](#_Toc414437290)

[23.14. Miscellaneous 232](#_Toc414437291)

[23.14.1. Fire Protection 232](#_Toc414437292)

[23.14.2. Lifebuoys 232](#_Toc414437293)

[23.14.3. Hydrants 232](#_Toc414437294)

[23.14.4. Boots Washing Unit 233](#_Toc414437295)

# Introduction

These Requirements for Civil Works are to be read in conjunction with the Employer’s Requirements (Volume 3-1), that is the following Sections:

Section 1 General Requirements for the execution of Works

Section 2 Particular Design and Process Requirements

Section 3 General Specification for Mechanical Works

Section 4 General Specification for Electrical Works

The Contractor shall offer the whole works including civil, mechanical and electrical parts, so that the aim of the project is completely fulfilled, as specified. It is the responsibility of the Contractor to include in his offer all civil works, deliveries and services required for the complete Works, and to state the exact quantity and dimensions as necessary to suit his design of the Works.

The quality and kind of the civil works, deliveries and services shall be as specified in the Tender Documents. Additional components have to be selected by the Contractor and must be described in detail in his offer. Any such component shall fulfil the uniform high quality standard that is required for the whole Civil Works.

Notwithstanding the subdivision of the specific Requirements under different headings, every part of it shall be deemed supplementary to and complementary of every other part.

The indicative drawings of the WWTP and appurtenant elements are attached in Volume 5 of this Tender Dossier.

## Standards and Regulations

National Standards or harmonised EU-Standards in their latest Edition shall be used throughout this Contract, generally. Authoritative are all standards that are valid at the location of the Plant during the time of implementation.

*EU-harmonized German DIN-Standards are prevailing if not stated otherwise. As a minimum, EU-harmonized national standards and codes shall always be satisfied, if applicable.*

The conditions specified in these general specifications are minimum requirements for all deliveries and performances. If special requirements are given for particular items they apply only to these particular items. The Contractor shall propose Standards for the execution of the Works, which shall be approved by the Engineer. A list of Standards is included in Section 1 of these Employer’s Requirements.

## Scope of Works

The whole of the Works, concrete-, sewer-, road works and buildings shall be build new and of first class manufacture and in every way suitable for wastewater works purposes and shall be completed generally in accordance with the intent of the requirements and the conceptual design.

The Requirements for Civil Works are based on the conceptual design for completion of a new WWTP. It is developed for an activated sludge treatment plant with carbon & nutrient removal and anaerobic sludge stabilization, and as an alternative with additional nutrient removal; this process technology shall be adopted by the Contractor as the basis for his Proposal and subsequent Works.

The scope of works that is covered by this Section of the specific Requirements includes not only the delivery, completion, installation and commissioning of the civil works, but also internal and external pipework, valves and metalwork.

## List of abbreviations

|  |  |  |
| --- | --- | --- |
| **%** | shall mean | per cent |
| **c** | shall mean | centre |
| **CA** | shall mean | Contracting Authority |
| **CESWI** | shall mean | “Civil Engineering Specification for the Water Industry”, 5th Edition” published by UKWIR Ltd., WRc plc, Franklin Road, Blagrove, Swindwon, Wiltshire, SN5 8YF |
| **Day** | shall mean | Calendar Day |
| **DD** | shall mean | Detailed Design |
| **DIN** | shall mean | German Standard |
| **DN** | shall mean | nominal diameter |
| **EN** | shall mean | European Standard |
| **FFL** | shall mean | Final floor level |
| **h** | shall mean | hour |
| **HDPE** | shall mean | High density extruded polyethylene |
| **ISO** | shall mean | International Standards Organization. |
| **kg** | shall mean | kilogram |
| **km** | shall mean | kilometer |
| **kW** | shall mean | kilo Watt (1000 Watts) |
| **l** | shall mean | liter |
| **L.S.** | shall mean | lump sum |
| **m** | shall mean | meter |
| **m/d** | shall mean | man-day |
| **m²** | shall mean | square meter |
| **m³** | shall mean | cubic meter |
| **mASL** | shall mean | Meters above see level |
| **mm** | shall mean | millimetre |
| **mm²** | shall mean | square millimetre |
| **Month** | shall mean | 30/31 Calendar Days |
| **MSDS** | shall mean | Material Safety Data Sheet |
| **pcs** | shall mean | pieces |
| **PE** | shall mean | Population Equivalent |
| **PM** | shall mean | Project Manager |
| **PVC** | shall mean | Polyvinyl chloride |
| **QAS** | shall mean | Quality Assurance System |
| **RC** | shall mean | Reinforced Concrete |
| **t** | shall mean | tone (1000 kg) |
| **TA** | shall mean | Technical Assistant |
| **TR** | shall mean | Technical Requirements |

# Demolition and Protection of Works

## General

The demolition of structures includes the demolishing of all kinds and grades of bricks, wooden structures, plain concrete and reinforced concrete, pipes, all requisite shoring and strutting or other supports incidental to demolition works, the removal of debris from site, final site clearance and making good of disturbed parts.

The demolition works to be carried out under this Contract on the sites for constructing the works may comprise of retaining walls, concrete pavements, small concrete structures, sheds and some buildings.

Details of the buildings and structures to be demolished by the Contractor shall be ascertained during the construction of the Works and shall be to the approval of the Engineer. The Contractor shall make necessary allowance in his work programme for the necessary demolition works.

The demolition shall be carried out including the foundations up to a depth of 0.5 m below final ground level unless directed otherwise by the Engineer.

The Contractor shall be obliged to undertake a survey in order to get sufficient information regarding the structures to be removed before submitting his tender.

The Contractor shall, amongst other risk investigations, examine the features of the structures, and ensure whether any shock or vibration could damage surrounding executed work, fixed equipment or any existing buried services and investigate the existence of any toxic or flammable substances or asbestos. Prior to the commencement of any demolition work, the Contractor shall be obliged to complete his survey in order to obtain any outstanding information as required under BS 6187. However, under no circumstances shall the Contractor have any right of claim in case he shall encounter, either through the completion of his survey or during the carrying out of the demolition work, any unknown problems of any nature.

The Contractor shall be obliged, prior to the commencement of any demolition work, to disconnect all affected existing live services according to the directions and instructions of the Engineer and any relevant Statutory Authority. In this respect the Contractor shall be obliged to obtain on time all necessary permits and provide the necessary notices to all parties concerned.

The Contracting Authority shall have the option of retaining ownership of any materials arising from demolition and may remove them at his own expense. In the absence of the Contracting Authority giving reasonable notice of his intention to take possession of such materials, ownership shall revert to the Contractor who shall become responsible for removal from site and disposal.

The Contractor shall comply with BS 6187 (“Code of practice for demolition“).

## Workmanship

Before moving equipment into the Site and commencing operations the Contractor shall establish to the Engineer's satisfaction that the method of demolition proposed by the Contractor is such that he can keep any nuisance arising from dust, noise, and vibration to an acceptable level and ensure the safety of structures adjacent to those to be demolished. The use of explosives is strictly prohibited.

All materials arising from the demolition and clearance of water lines, buildings, structures and other objects mentioned above shall become the property of the Contractor and shall be disposed off site.

All voids shall be re-filled with soil compacted to the same density as the surrounding soil and the surface shall be finished to the existing ground level and to the satisfaction of the Engineer.

Demolition of reinforced concrete structures shall be carried out using approved methods and in accordance with any safety regulations of the local municipality. The Contractor should note that a Building Permit might be required for demolition work.

Except as noted below, debris arising from demolition shall be removed from the Site promptly and disposed of in a place and in a manner acceptable to the local municipality.

Underground structures shall be broken out to a depth required for removal of them. Sumps, pits, chambers and the like shall be properly cleaned out and filled with clean demolition hard-core (if required or instructed by the Engineer), excluding any wood, plastic, sheet metal, loose reinforcement steel and the like.

Demolition of walls, tanks, and plates inside building to be rehabilitated will be performed with the required care, without damaging the stability of the structure.

Where required or directed by the Engineer, the existing structure will be temporary reinforced to assure the stability. The Contractor will submit for the Engineer's approval the methods applied for demolishing and the proposed temporary safety measures. The Engineer's approval shall not relieve the Contractor of any of his responsibilities under the Contract.

## Protection of Existing Objects

The Contractor shall not demolish or remove any existing buildings, structures or other objects including trees, whether indicated on the drawings or not, unless on a specific protect from damage any of these objects, including houses, buildings, fences or trees, which are situated on or near the site(s).

The Contractor shall:

* Protect benchmarks, existing structures, fences, roads, sidewalks, paving and curbs against damage from equipment and vehicular traffic;
* Protect aerial, surface, or underground utility lines or appurtenances, which are to remain;
* Repair damages.

Any property situated in close proximity to the Works shall be protected against any damage that could be caused by vehicles, subsidence, vibration, etc. The Contractor shall either repair any damage caused or the Contractor shall pay for the works to be repaired to the condition of the property prior to damage and to the satisfaction of the Engineer.

Around utilities as there are electricity pylons an area of 5 m shall be kept free from site works unless there is necessity of construction works according to the design documents.

Construction works and trench excavation at utilities, along existing supporting walls, at dams and embankments shall be executed under strictly avoidance of settlements. Earth works or any other construction work close to existing structures or embankments as mentioned before shall be kept out of the sphere of earth static influence. This is defined by a borderline measured at the level at the soil surface, that is attached to the structure or the bottom of the embankment, 1 m horizontally away and then sloping down with 45°. For such kind of works necessary approval of the relevant authorities shall be taken. For all work that interferes with this line the contractor shall provide static calculations, that have to be approved by an independent consultant. The contractor has to apply a suitable method for pit/trench sheeting and bracing with low vibration and low concussion.

The Contractor shall provide support necessary to ensure the stability of the excavation and adjacent roads and structures. The support may be made with sheet-pile walls, holding walls, open caissons or pneumatic caissons etc. Any such support shall be deemed to be included in the relevant prices for excavations for structures, installation of pipes and cables, and others.

## Filling and Sealing of Abandoned Pipelines

Where existing sewers are connected to the new systems, the length of the sewer downstream to the connection, which is not incorporated into the new, shall be abandoned.

Buried pipelines to be abandoned shall be sealed with mass concrete plug of minimum length 1 m at either ends and between manholes.

Manholes on abandoned pipelines shall be demolished to a depth of 0.5 m below final ground level and the void filled with hard core or other approved fill material and surface reinstated to a finish similar to that of the surrounding area.

Exposed pipelines to be abandoned shall be demolished to a depth of 0.5 m below final ground level and all debris disposed of off site.

## Disposal of Demolition Materials

If applicable, all materials to be removed from the site as result of demolition; dislocations etc. are the property of the Beneficiary.

Irrespective of the use to which the Beneficiary intends to put the materials or articles over which it retains ownership, all costs incurred in transporting and storing them at the place indicated by Beneficiary /Engineer shall be borne by the Contractor.

It is the sole responsibility of the Contractor to displace the demolished materials upon written approval by the Engineer in case that Beneficiary will decide to not keep and store the demolished materials.

## Refilling and Finishing

All voids shall be re-filled with soil compacted to the same density as the surrounding soil and the surface shall be finished to the existing ground level and to the satisfaction of the Engineer.

## Permission

Permission for demolishing existing buildings and structures shall be applied in writing to the Engineer and shall be accompanied with a demolition programme. The Contractor will be responsible for environmental sound disposal of materials under permission from the relevant local Authorities.

Prior to the commencement of any demolition works the Contractor shall submit a Method Statement, incl. measurements, bills of materials, description/spec’s of disposal materials and disposal routes, safety plans, etc. for the approval by the Engineer.

No demolition shall take place before obtaining the Engineer’s permission and the area has been provided with all necessary relevant temporary works and/or diversions, which have been either requested or authorised by the Engineer.

# Clearing and Grubbing

## Clearance of Sites

The Contractor shall clear the reservation widths for pipelines, road facilities and the sites of structures free of all vegetation, trees up to 0.5 m girth measured 1.0 m above ground level, and all superficial obstacles such as road surfaces, curbs, bricks, debris, rubbish and/or other objectionable matter.

Site clearance shall also include the inspection of the construction site, the record of existing status by photo documentation and levelling. [new]

When ordered by the Engineer in writing, the Contractor shall also clear the sites of trees over 0.5 m girth, buildings and/or structures.

The extent of Contractor’s clearing and grubbing operations shall be the minimum practicable necessary in the opinion of the Engineer for the construction of the Works.

## Protections

Trees and/or other vegetation designated on the Drawings or directed by the Engineer for preservation shall be kept free from clearing operation and be protected from injury during execution of the Works.

## Road Furniture

The Contractor shall re-install any road furniture (such as street lighting, traffic sign or traffic lights) that has to be removed during the progress of the Works.

Installation of the road furniture shall take place at its original location, in a condition at least equal to that prior to removal and as soon as practicable after completion of pipe laying at a particular location.

## Disposals

All vegetation, trees, etc. arising from the clearing and grubbing operations shall pass to the ownership of the Contractor and shall be dumped at a depot to a location directed by the Engineer. Remnants of vegetation, including trees, stumps and roots, shall be disposed of off site by the Contractor unless otherwise directed by the Engineer.

## Blasting

No blasting shall be carried out without the written permission of the Engineer.

When necessary, blasting for clearing boulders and/or rock masses will be permitted only on written approval of the Engineer and when proper precautions are taken for the protection of all persons, the Works and public and private properties.

Blasting shall be carried out in a controlled manner and to the required depth, amount and extent necessary and only with explosives of such quantity and strengthand in such locations as will not structurally damage the material to be blasted outside the prescribed limits. Any damage to the Works or properties arising from the blasting shall be repaired by the Contractor to conform to the condition existing prior to damage.

Before any blasting is carried out, the Contractor shall ensure that adequate measures that are necessary for the safety and protection of persons and property against injury or damage has been provided and warning signs and signals has been installed all to the satisfaction of the Engineer and other Authorities concerned with safety and public order.

Explosives and detonating caps shall be stored, handled and used as prescribed by the Law and Regulation of administrative agencies of the Republic of Montenegro. Only qualified and authorised personnel shall handle and use explosives.

## Notice of Commencement

The Contractor shall give to the Engineer written notice of his intention to commence the clearing and grubbing and/or blasting operations. The works shall not be commenced until written approval has been received from the Engineer.

The Contractor shall ensure that all clearing, grubbing and blasting are carried out far enough in advance of other construction operations within the relevant areas in order to avoid delays.

# Earthworks

## Standards

The main standards are, but are not limited by, the following:

## Design, Loading Assumptions

The Contractor shall use the data in the documents and results of the site investigations to design in detail every aspect of the Works, permanent or temporary, which is affected by the subsoil. This stability of design shall be entirely the Contractor’ responsibility.

DIN 1054 Foundation soil, admissible loads

DIN 1055 Loading assumptions

DIN 4020 Geo-technical investigations

DIN 4021 Investigation of foundation soil

DIN 4022 Foundation soil and groundwater: classification

DIN 4023 Boring for foundation soil and groundwater investigation

DIN 4094 Foundation soil: investigation by probing

DIN 18196 Earthworks: soil classification

ENV 1997-7 Eurocode 7: Design and calculation of geo-technical structures

### Site investigations

The geotechnical assessment report given in the tender documents provides an outline of the geotechnical status of the and there is a need for additional investigations.

Geotechnical Investigation in situ shall be performed in accordance with EN 1997-1:2008 and EN 1997-2:2008 and corresponding standards.

Sampling and laboratory testing shall be compliant to EN 1997-2:2008 and corresponding standards.

Results on geotechnical survey shall comply to EN 1997-2:2008

After the commencement of the Works, the Contractor shall update the surveys according to the general layout and hydraulic profile of the plant structures in the contractor's detailed design.

The fieldwork to be carried out by the Contractor shall comprise:

• vertical test borings

• disturbed & undisturbed sampling and laboratory tests

• penetration tests (S.P.T. and/or C.P.T.)

• plate bearing tests

• permeability tests

• ground water table and ground water quality determination

• geophysical investigations are not required.

The site investigation work shall be carried out using modern methods and equipment and by fully competent staff under the supervision of a qualified Contractor’s Representative. The equipment employed shall be such as to provide the necessary data.

In the leachate treatment plant, the number of vertical test borings shall be a minimum of 5 as approved by the Engineer and the borehole depths shall be min.12 m, or natural gravel layer depth plus 5 m penetration into sound gravel layer, whichever is smaller. In case of absence of the gravel layer, depth of borehole will be 15 m, or to the good compacted soil and depth approved by the Engineer.

The Contractor shall carry out the investigations, tests and reports according to the following rules, standards and specifications, required by Ministry of Sustainable Development and Tourism of Montenegro.

Company which will perform geotechnical research works has to be Registered for performing of geological research works, in accordance to the Law for geological research (Official Gazette of Montenegro No. 28/93, 27/94, 42/94, 26/07 and 28/11)

DIN 18121 Water content test

DIN 18122 Consistency limits test

DIN 18123 Grain size distribution

DIN 18124 Grain density

DIN 18125 Density of cohesive soils

DIN 18126 Density of non-cohesive soils

DIN 18127 Proctor test

DIN 18128 Ignition loss

DIN 18129 Lime content

DIN 18130 Water permeability factor

DIN 18132 Water intake capability

DIN 18134 Loading test

DIN 18135 One-dimensional compression test

DIN 18136 One-axial compressive strength

DIN 18137 Shear strength

### Geotechnical report and ground improvement

The Contractor shall submit to the Engineer a Soil Investigation and a Geotechnical Report incorporating a record of all the investigation work carried out by him. The Report shall include boring logs, borehole coordinates, records of field and laboratory tests, records of water level observations and recommendations as to the bearing capacity and deformation properties of the soil and water inflow. The report shall be prepared in English. Five copies of this Report shall be submitted to the Engineer within one month of completing the field work. Laboratory tests shall be carried out in the laboratory approved by the Engineer.

The report shall cover the following for each and every structure,

• ultimate and allowable bearing capacity of foundation soil

• liquefaction analysis

• immediate and consolidation settlements, and heave at excavations

• drainage system of excavations

• single pile capacity (if necessary)

• ground improvement design (if necessary).

Any ground treatment proposed by the Contractor to improve the bearing capacity and/or settlement characteristic of the soil must be supported by a full method statement -including design calculations and design drawings- with a statement of the minimum performance to be achieved.

In the selection of ground improvement method, the time limitations of the Contract shall be taken into consideration. The methods listed in the Employer's Requirements may be used and all methods are subject to the approval of the Engineer. Where directed by the Engineer the Contractor shall carry out a field trial of the proposed treatment to demonstrate that it meets the stated performance criteria.

All in-situ verification of ground improvement shall be made by CPT or SPT test after ground improvement works

### Soil replacement

Soil replacement involves excavating the soil that needs to be improved and replacing it. Excavated soil shall be replaced with compacted granular soil (Sand & gravel) with more suitable properties for the proposed application.

Method and material or soil replacement shall be approved by the Engineer.

### Admixture stabilization

Admixture stabilization consists of mixing or injecting admixtures such as cement, lime, fly ash or bentonite into a soil to improve its properties. Admixtures can be used to increase the strength, decrease the permeability or improve the workability of a soil. Admixtures can fill voids, bind particles, or break down soil particles and form cement. The general process of admixture stabilization consists of (1) excavating and breaking up the soil, (2) adding the stabilizer and water, if necessary, (3) mixing thoroughly, and (4) compacting the soil and allowing it to cure.

During stabilization of soils with admixtures, the most important observations are the amount of admixture and water mixed into the soil, the amount of mixing performed, and the amount of compactive effort used on the fill. The moisture content and density of the fill can be determined in the field. The curing time and conditions should also be recorded. Samples should be taken for laboratory testing.

Method of admixture stabilization shall be approved by the Engineer.

## General Instructions

### Excavation Method Statement

The Contractor shall prepare a method statement of his proposal for earthworks operation for each particular part of the Works to be constructed at any one time, detailing the location, programme of excavation, temporary supports, ~~and~~ the placing and handling of the spoil, and ground stabilisation.

The Contractor shall submit for the Engineer’s approval his proposed method statement at least 14 days before his intended date to commence earthworks on each particular part of the Works.

### Notice of Commencement

The Contractor shall give to the Engineer at least 7 days written notice of his intention to commence earthworks on any part of site and shall furnish the Engineer with all ground levels, site photographs showing the existing conditions and levels and other particulars he may require for the purpose of carrying out measurements.

Earthworks shall not be commenced until written approval has been received by the Contractor from the Engineer.

### Traffic requirements

The Contractor shall comply with National laws and codes of practice in respect of this clause.

Before any work in or affecting the use of any highway is commenced, the Contractor’s proposed method of working shall be agreed with and confirmed in writing to the Engineer and the Highway and Police Authorities.

Throughout the Contract, the Contractor shall co-operate with the Highway and Police Authorities concerning works in, or access to, any highway. The Contractor shall inform the Engineer of any requirements of, or arrangements made with, the Highway and Police Authorities.

Where the diversion of any existing carriageway, footway or public right of way is temporarily made necessary by the Works, the Contractor shall provide and maintain an alternative, acceptable to the Engineer, which shall be operational before any interference with the existing way takes place.

Where ramps are required, they shall be provided and maintained to a standard suitable in all respects for the class or classes of traffic or pedestrians requiring to use them.

The Contractor shall maintain emergency vehicle access to all properties at all times.

Where single line traffic operation is unavoidable, the Contractor shall provide a proper system of traffic control as agreed by the Engineer.

### Earthworks to Lines and Levels

The whole of the earthworks for the several parts of the Works shall be carried out to the dimensions and levels shown on the Drawings, or to such other dimensions and levels as may be ordered by the Engineer.

For the purpose of the Contracting Authority’s Requirements, the term ”ground level” shall refer to the ground surface before the start of earthwork operations, but after the operations of clearing and grubbing. Where the expression ”formation level” is used in the Technical Requirements it shall mean the foundation level of the structure concerned including the blinding concrete.

### Stripping of Topsoil

Where ordered by the Engineer topsoil shall be stripped from the whole or part of the site to a depth of 25 cm or to such other depths as indicated in the Contract Documents or such other depths and over such areas as the Engineer may direct, and set aside for reuse as a separate operation prior to any further excavation which may be required.

The work includes transport on site and storage of soil on stable and well-drained stockpiles within the area affected by construction operations.

Topsoil shall include any surface material capable of supporting vegetation and suitable for use in soiling areas to be grassed or cultivated.

The Contractor shall not dispose of surplus topsoil without the written permission of the Engineer. The cost of his shall be assumed to be included in the rates and prices and no payment shall be done.

### Relocation of Possible Utilities and Trial holes

The Contractor shall take all steps necessary to find, protect and safeguard any drains, pipes, cables and similar services encountered, already installed or to be installed, for the duration of the contract in order to keep them in good working condition. Should the services become damaged during the course of the works, then the Contractor shall be responsible for liaising with the responsible utility companies or organizations and arranging for the repair of that service and bear all costs associated with the repair of the service.

Information as may be given in the contract in relation to the present condition and character of the existing structures, roadways, embankments and the like and in relation to the dimensions of various parts of the existing structures, the position, extent and particulars of drains, pipes, cables and the like, is given without guarantee of accuracy and neither the Employer nor the Engineer will be liable for any discrepancy therein.

The absence of such information shall not relieve the Contractor of this liability for the cost of any repair work necessitated by damage caused by him to such mains and services in the course of his work and for the cost of all losses arising from their disruption.

The Contractor shall obtain all available information, assistance, full permission and approval of all relevant utility companies or organizations regarding the positions and/or relocation of mains and services, serving notices of intent to start work as may be necessary in accordance with all the local laws and regulations. He shall make this information available to the Engineeras soon as he obtains it. He shall agree with the Engineerany trial excavations, which may be necessary to confirm or establish these locations. All costs for executing trial holes shall be deemed to be included in the Contractor's quotation for the earthworks. All relocating works shall be carried out two weeks in advance of execution of the relevant work.

The Contractor shall obtain all available information, assistance, full permission and approval of all relevant utility companies or organizations regarding the positions and/or relocation of mains and services, serving notices of intent to start work as may be necessary in accordance with all the local laws and regulations. He shall make this information available to the Engineer as soon as he obtains it. He shall agree with the Engineer any trial excavations, which may be necessary to confirm or establish these locations. All costs for executing trial holes shall be deemed to be included in the Contractor's quotation for the earthworks. All relocating works shall be carried out two weeks in advance of execution of the relevant work.

### Disposals

All surplus materials arising earthworks shall pass to the ownership of the Contractor and shall be disposed of off-site.

## Excavations

### Extent of Excavations

The extent of excavations shall be the minimum necessary or practicable in the opinion of the Engineerfor the construction of the Works.

Excavations shall be carried out to such dimensions (depth and width) as will permit adequate dewatering, proper support of the sides of the excavation, the erection of shuttering, placing of concrete and fill including compaction and any other construction operation. EN 1610 shall be applied.

The construction of open trenches shall, at any time, be limited to lengths previously approved by the Engineer, in writing. Unless otherwise approved by the Engineer in writing work on each approved length shall be completed to the satisfaction of the Engineer before work on any new length is commenced.

No excavations with battered sides will be permitted in public highways, private gardens or within 30 m of any building or other structure. In the event of the Contractor adopting the method of excavation with battered sides his obligations for providing supports shall be as specified in the Sub-clause 1.4.4. Slips, Falls and Excess Excavations.

### Excavation of Unsound Material

If any unsound material occurs in foundations of structures, the Contractor shall remove it and dispose of it to the satisfaction of the Engineer. Unless otherwise specified or ordered by the Engineer, the Contractor shall fill the voids in the foundations so formed with lean mix concrete. No payment shall be done for this.

If any unsound material occurs in pipeline trenches, the Contractor shall remove it and dispose of it to the satisfaction of the Engineer. Unless otherwise specified or ordered by the Engineer, the Contractor shall fill the voids in the pipeline trenches with approved fill material.

If the Contractor encounters any materials, which in his opinion may be unsound, he shall immediately inform the Engineer who will then instruct the Contractor in writing as to whether or not the said material shall be treated as unsound.

The cost of dealing with the unsound material shall be borne by the Contractor if, in the opinion of the Engineer, the cause of unsoundness is due to failure of the Contractor to comply with the Contracting Authority’s Requirements, including keeping the excavation free from water.

### Slips, Falls and Excess Excavations

Every precaution shall be taken by the Contractor to prevent slips, earth and other material in the excavations. In the event of slips or falls occurring or in the event of excavation being made in excess of the minimum necessary or practicable for the construction of the Works the voids so formed shall be filled. In all cases where the voids or unsound material so formed when backfilled would provide support for the permanent Unless otherwise specified or ordered by the Engineer, the Contractor shall fill the voids so formed with concrete grade C8/10 or with suitable granular material to the approval of the Engineer.

Unsound material shall include:

* Peat, timber and perishable material
* Clay with a liquid limit exceeding 80 and having a plasticity index exceeding 55
* Materials having moisture content greater than the maximum permitted for such materials.

In the event of any trench for pipelines exceeding the maximum allowable widths as specified or shown on the Drawings the Engineer will order the restoration of the trench width or the use of an alternative bedding material or such other remedial action as in his opinion is necessary. The Contractor shall then carry out the measures so ordered by the Engineer and shall have no claim against the Contracting Authority for any additional costs resulting from such instructions.

### Excavation to be Kept Free From Water

The Contractor shall as required by the Engineer keep excavations free from water and sewage whether caused by ground water, tides, floods, storms or otherwise so that the Works shall be constructed in dry conditions. The Contractor shall keep the sub-soil or accumulated water or sewage at a level lower than the bottom of the Permanent Works for such a period as the Engineer shall direct.

For dewatering of the excavation one of the following techniques can as examples be used:

* Dewatering with pumping from wells
* Pumping directly from the excavation;
* Pumping from drilled and filtered wells
* Pumping from acicular filter systems.

The usage of the above methods will depend on the soil characteristics as described in the geotechnical investigations.

Unless otherwise specified the Contractor shall drill and finish wells, furnish, install, maintain and operate all necessary pumping and other equipment for keeping excavations free from water as required for construction of each part of the Works and fit to the chosen methods for bracing and sheeting of excavations. The Contractor shall ensure that sufficient stand-by plant and emergency power supply is available on site at all times to avoid any interruption to continuous dewatering.

The Contractor’s method of keeping excavations free from water will be subject to the approval of the Engineer.

In the event of the Contractor requiring drainage pipes, channels or sub-drains the Engineer may permit these to be constructed below the level of and within the width limits of the permanent Works provided he has approved the details of the Contractor’s proposals. No sub-drainage pipes shall be left in unless they are filled with lean mix concrete or other approved material. Any sub-drainage that the Contractor constructs below the Permanent Works shall, if left in place, provide supports at least equal to that which would have been available if the sub-drain was not present.

No water shall be discharged into any watercourse or sewer without the Contractor having first obtained all necessary consents and the permission in writing of the Engineer. Such permission shall not be granted unless the Contractor shall have provided to the satisfaction of the Engineer an efficient settling basin or sand trap through which all such water shall pass before discharge into the said watercourse or sewer.

### Crossing Watercourses

Contractor shall get the necessary permissions for crossing existing infrastructure from related Authorities and provide necessary data requested by these Authorities.

Contractor shall take all necessary safety precautions before starting the Works. All intersections and parallel constructions shall be subject to the approval of the Engineer.

Where pipelines and box culverts intersect rivers or flood beds, the route shall cross the bed in perpendicular direction where possible. Finished cross section of the river crossing shall not disturb the natural flow in the river and flood water. Pipeline and box culverts shall be buried at least 1m below the river bed.

Pipes shall be protected by a reinforced concrete box, and shall be secured against uplift when empty.

Where the excavation crosses streams, ditches, culverts and other watercourses the Contractor shall be deemed to have included all the additional measures and costs necessary for the proper construction of the Work at these crossings including maintaining the full flow of water.

River crossing construction shall be made under dry conditions, and where necessary trench shall be protected by sheet pile walls and drainage pumps. During every stage of construction, diversion pipes and channels shall be made available for safety of works.

### Intersections with roads, highways and railroads

Contractor shall get the necessary permissions for crossing existing infrastructure from related Authorities and provide necessary data requested by these Authorities.

Contractor shall take all necessary safety precautions before starting the Works. All intersections and parallel constructions shall be subject to the approval of the Engineer.

After crossing the paved roads, drainage systems sidewalks and pavements shall be restored to original position by the Contractor. New pavement repair width shall be proportional with the road width.

At locations where new pipelines or culverts cross the roads, the soil cover above the pipe crest or top of box culvert shall be at least 1.50 meters.

At locations where new pipelines and culverts cross railroads or major highways, the crossing shall be made by pipe jacking or similar method without disturbing traffic.

### Formation Level

The formation level of excavations shall be finally trimmed by hand, or such other method as may be approved or ordered by the Engineer, immediately prior to the laying of pipes or to concreting.

The formation level shall be excavated and back-filled to achieve a plane and even area as required for pipe laying or concreting except as necessary for proper pipe joint holes which shall be excavated under every socket or collar to such depth that the socket or collar shall not touch the bottom of the hole and where shown on the Drawings to not less than depth specified.

### Inspection by the Engineer

The Contractor shall report to the Engineer when excavations are ready to receive pipes or concrete foundations or when the specified levels or limits of any excavation are reached and shall not proceed with pipe laying, concreting or other works until they have been inspected passed and approved by the Engineer. Any pipe laying, concreting or other work carried out without prior approval of the Engineer shall be removed immediately at the Contractor’s expense.

The Engineer may order either in situ or other tests as specified to determine the nature and bearing capacity and deformation properties of the soil strata. If he considers that any part of the ground is by its nature unsuitable he may direct the Contractor to carry out any measure to improve the soil conditions or to excavate further. Such further excavation shall be refilled to the specified levels or limits with concrete, selected excavated material or selected imported material.

Should the material forming the bottom or sides of any excavation, while acceptable to the Engineer at the time of inspection, subsequently become unacceptable due to exposure to weather conditions or due to groundwater, flooding, puddles, or have become soft or loose during the progress of the Works, the Contractor shall by the approved methods remove such damaged, softened or loosened material and excavate further to a sound surface. Such further excavation shall be held to be “Excess Excavation” and material emanating there from shall be removed from the site.

### Disposal of Surplus Excavated Material

Deposits of surplus suitable material and unsuitable materials are in the following referred to as "soil dumps". Generally, the Contractor shall transport and dispose of all excavated material not required for the works. The locations proposed by the Contractor for disposing of excavated material whether temporarily or permanently, shall be subject to the approval of the Engineer. The Employer will assist in locating a suitable soil dump.

The Contractor shall be responsible for negotiating and securing suitable areas for disposal of surplus excavated materials and shall pay any fees or surplus excavated materials and shall pay any fees or other payments associated with such disposal. These shall be included in his rates and prices.

In connection with the disposal of excess spoils, the Contractor shall be responsible for the following during the Contract period:

* To upgrade the strength and the quality of the existing access road(s) and maintaining the same in good order and final reinstatement.
* Dewatering of the tipping area(s) by means of porous concrete pipes laid at the bottom of the valleys or as agreed with the Engineer.
* To do the activities on unloading, spreading, levelling placing the soil into embankments, as necessary, in order to keep the top(s) in good, safe and manageable order.
* To keep the third parties from using the tipping area(s) and no claims will be accepted by the Engineer for any extra work associated with soil disposed of by others or requests for additional tipping area should the existing one become saturated due to use by other parties;
* Keeping vehicles clean when leaving the tipping area(s) and to ensure they do not contaminate public roads.

### Tests on Ground Water

During the course of the excavation work the Engineer will require samples of the ground water to be taken for testing to ascertain the present of harmful substances. The testing shall take place in accordance with Rule book No. 15/90 and DIN 4021 T3.

The tests shall be performed in the beginning of the execution works in a suitable laboratory before starting any concrete work. The results concerning adverse affects on concrete shall be evaluated according to Rule book No. 15/90 and DIN 4030.

## Geotextiles

### Standards and Norms

The Contractor shall carry out the works described in accordance with DIN EN 13250. The materials shall comply to the following standards as a minimum:

EN ISO 10319 Tensile strength (wide width)

EN ISO 10320 Identification of geotextiles at construction site

EN ISO 10321 Tensile test on seams and joints by wide width method

EN ISO 10722 Damage to geotextiles during installation in grained material

EN ISO 11058 Water Flow (normal to plane)

EN ISO 12236 Static puncture strength (CBR)

ENV 12447 Resistance against hydrolysis

EN ISO 12956 Characteristic opening size

EN ISO 12957 Friction values

EN ISO 12958 Water flow capacity (in plane)

ENV ISO 12960 Resistance against liquids

EN SIO 13427 Abrasion test

EN ISO 13431 Tensile creep test

EN ISO 13437 Sampling and testing of geotextiles at construction site

ENV ISO 13438 Resistance against oxidation

### Application

The applications of geotextile fabrics are divided into the following three main classes:

Drainage- under all rubble rip-rap, including cyclopean stone and under gabions; wrapped around drains, pipe joints, and edge-drains; filter behind walls, etc.;

Erosion Control: silt fence and staked silt barrier;

Stabilisation: separator between embankment and soft subsoil, reinforcement and pipe bedding.

### Material Requirements

The geotextile shall be the type appropriate for the intended use. The geotextile fabric shall be a woven or non woven fabric consisting of long-chain polymeric filaments or yarns such as polypropylene, polyethylene, polyester, polyamides or polyvinyl chloride formed into a stable network such that the filaments or yarns retain their relative position to each other. The base plastic shall contain stabilisers and/or inhibitors to make the filaments resistant to deterioration due to ultra-violet light (except for subsurface and stabilisation classification), heat exposure and potential chemically damaging environment. The fabric shall be free of any treatment, which may significantly alter its physical properties. The edges of the fabric shall be selvaged or otherwise finished to prevent the outer yarn from pulling away from the fabric.

Synthetic filter fabric used for **reinforcing grades** (in water environments under block or rock covers) shall conform to the following specifications:

|  |  |
| --- | --- |
| **Fabric Properties** | **Requirements** |
| 1. Tensile Strength | min. 50 kN/m |
| 1. Tensile Strength at 5 % elongation | min. 60% of tensile strength acc. to No.1 |
| 1. Elongation at max. load | max. 10% |
| 1. Puncture resistance | min. 6 kN |
| 1. Cone drop penetration | max. 8 mm |
| 1. 10% fractile of pore size distribution | 0.15 – 0.4 mm \* |
| 1. Permeability normal to plane | 15 - 22 l/m2/s \* |
| 1. Weight | min. 200 g/m2 |

Synthetic filter fabric used as filter (protection of drainage pipes etc.) shall conform to the following specifications:

|  |  |
| --- | --- |
| **Fabric Properties** | **Requirements** |
| 1. Tensile Strength | 1. min. 25 kN/m |
| 1. Tensile Strength at 5 % elongation | 1. min. 30% of tensile strength acc. to No. 1 |
| 1. Elongation at max. load | 1. max. 25% |
| 1. Puncture resistance | 1. min. 2 kN |
| 1. Cone drop penetration | 1. max. 15 mm |
| 1. 10% fractile of pore size distribution | 1. 0.4 – 0.5 mm \* |
| 1. Permeability normal to plane | 1. 100 l/m2/s \* |
| 1. Weight | 1. min. 120 g/m2 |

\*) Fabric material shall have a permeability and characteristic pore size as required by the specific need or directed by the Engineer. Generally, low porosity fabric shall be used at toes of slopes and around inlets. High porosity fabric shall be used in drainage ways.

Fabric material shall have a minimum of 10 years of expected usable construction life at a temperature range of 0° to 40°C.

### Testing

The Contractor shall furnish two certified copies of a test report from the manufacturer certifying that the geotextile to be incorporated into the completed project meets the requirements of this Specification. The certified test reports shall be attested to be a person having legal authority to bind the manufacturing company. The Contractor shall also furnish two 100 x 100 cm samples of the geotextile for product identification and any onsite testing. In addition, the manufacturer shall maintain test records as required by this Specification. These records shall be made available to the Engineer on request.

### Execution and Workmanship

The fabric shall be wrapped in a protective covering which is sufficient to protect it from sunlight, dirt, and other debris during shipment and storage.

After placement, the geotextile shall not be left uncovered for more than 2 weeks.

Traffic or construction equipment will not be permitted directly on the geotextile.

Geotextile which becomes torn or damaged shall be replaced or patched. The patch shall extend 1 m beyond the perimeter of the tear or damage.

Overlaps shall be as specified by the manufacturer or as directed by the Engineer. In order to reduce overlaps, the geotextile fabric may be sewn together. Seams of the fabric shall be sewn with thread meeting the chemical requirements and minimum seam strength requirements given for the fabric and application. Sewn seams shall be lapped a minimum of 10 cm and double sewn.

Non sewn seams shall have a minimum overlap of 50 cm except where placed under water where the overlap shall be a minimum of 100 cm.

All seams shall be subject to the approval of the Engineer.

The geotextile shall be placed and anchored on a prepared surface approved by the Engineer. The geotextile shall be laid loosely so that placement of the overlying materials will not stretch or tear the geotextile. Where geotextile is placed above water, the backfill placement shall begin at the toe and proceed up the slope.

Where geotextile is placed under water, the long dimension shall be placed parallel to the direction of flow. Successive geotextile sheets shall be overlapped in such a manner that the upstream sheet is placed over the downstream sheet. As the geotextile is placed under water, the backfill material shall be placed on it to the required thickness. The geotextile placement shall not progress more than 15 m ahead of the backfill placement.

Rip-rap, stone filling (heavy) or stone filling (medium) shall not be dropped onto the geotextile from a height greater than 0.3 m. Slope protection and smaller sizes of stone filling shall not be dropped onto the geotextile from a height exceeding 1 m.

If the above conditions cannot be met, a protective layer shall be placed on top of the geotextile (i.e. wire mesh, steel wire fabric used for concrete reinforcement, etc.)

The surface upon which the geotextile is to be placed shall be within reasonable conformity to the proposed grade. The geotextile shall be laid loosely so that placement of the overlying material will not stretch or tear the geotextile. The overlying course shall be placed in 1 lift and compacted as approved by the Engineer.

The geotextile shall be placed to conform loosely to the shape of the trench.

After placing the filter material, the geotextile shall be folded over the top of the filter material to produce a minimum overlap of 30 cm. The geotextile shall then be covered with the subsequent course.

## Filling

### General

**Extensive Filling** is herein after referred to as provision of the final ground levels (including slopes), which are shown in the design, or raising of ground levels at the required locations (taking into account the thickness of cover necessary for landscaping).

**Back-Filling** is herein after referred to as backfill of excavations for structures or pipes.

Filling includes generally loading and transport of materials from intermediate stockpiles, placing of fill material in layers, adjusting of moisture content, compaction to the specified density and trimming of compacted surfaces.

No backfill work shall be carried out until approved by the Engineer.

Fill material shall not contain roots, frozen material, organic or otherwise unsuitable materials.

No fill material shall be placed in any of the permanent works until its foundation has been prepared as specified.

Fill materials shall be handled, placed, spread and compacted in such a manner as to avoid segregation of the fill and to obtain a stable, homogeneous compacted structure.

When organizing his work, the Contractor shall take due account of the climatic conditions, which may be expected in the area. Should placed material by any cause become unacceptable, the Contractor shall remove such material or shall process it until all specifications are met. Such work shall be performed at no additional cost to the Employer.

Unless otherwise specified or approved, the material used for backfill and fill shall be excavated material of particle size not exceeding 75 mm.

Backfill against the permanent works shall be selected, and free from boulders, cobbles, rock fragments and the like greater than 50 mm nominal size.

Imported fill materials shall comprise the following materials all in accordance with the relevant norms:

* Sand in fraction 0.1-2 mm
* Gravel in fraction 2-75 mm
* Boulders in fraction 75-100 mm.

Where fill will be used below structures and building floors, the material shall consist of durable gravel, broken stone, crushed concrete or sand with a particle size not exceeding 10 mm. The grading of the material shall be such that there is no migration of fines into the fill.

### Fill Materials to be provided by the Contractor

Except where otherwise specified, the Contractor shall be responsible for the location of suitable sources of natural materials for the execution of the Works, whether such sources are on the Site or not, and for obtaining all necessary permissions, including certificates of occupancy, quarry licences and water rights.

Materials available on the Site or materials made available or supplied by the Technical (if any) shall be used for the execution of the Works if the quality of such materials is sufficient.

It is the Contractor’s responsibility to obtain, transport and place materials when needed for the executions of the Works. The Contractor shall obtain the approval of the Engineer for the areas as well as for the materials he proposes to use.

Where specified or ordered by the Engineer, fill material for incorporation in the Works shall be obtained from approved borrow areas after the completion of any tests to confirm the suitability of the material.

On completion of excavation, the Contractor shall trim, grade and leave the borrow area in a tidy condition to the satisfaction of the Engineer and, if ordered, shall carry out without charge any further earthworks necessary to prevent accumulation of water in the area.

### Fill Materials Obtained from the Site Excavations

If the excavated materials found to be appropriate for fill, these materials can be used with the approval of Engineer up to level excluding topsoil. If it is not sufficient, additional fill material shall be provided according to the Technical Requirements. Excavation materials shall be sorted and graded.

### Preliminary Tests for Compacted Fill

If ordered by the Engineer, materials proposed for use as compacted fill (other than the materials previously excavated at the same location on the site) shall be tested on site in accordance with the procedures as prescribed in DIN 18196 to determine its characteristics and suitability.

### Filling not to Endanger Structures

The Contractor shall arrange the timing and rate of placing of back-filling or of filling to structures in such a way that no part of the Works is over stressed, weakened, damaged or endangered. The layers of material shall be so placed as to maintain adequate drainage and to prevent accumulation of water. In particular, the placing of material around concrete structures shall commence only after they have been completed and have attained their full specified strength. The material shall be placed so as to exert a uniform pressure around the structures.

Regardless of the method of back-filling adopted the Contractor shall ensure that back-filling to excavations is carried out to the satisfaction of the Engineer. The Contractor shall take all necessary precautions to ensure that no damage is caused to the Permanent Works or to adjacent structures.

Where backfill is to be placed on two or more sides of the structure, it shall be placed simultaneously on the opposite sides so that the difference in level never exceeds 0.30 m, or as otherwise instructed.

Filling material for excavations and for making up levels within the perimeter of structures shall be suitable material and shall contain no particular size in excess of 50 mm. The compaction of fill material within the perimeter of structures shall be carried out with equipment suited to the area being compacted.

### Back-filling of Excavations for Pipes or Cables

The bedding zone below, lateral and above the pipe or cable shall be filled and carefully compacted by a method approved by the Engineer to avoid change in alignment and level of the pipes or cables.

Unless specified otherwise the excavation for pipes or cables shall receive a minimum layer of approved bedding material below the pipe or cable of depth in the trench according to EN 1610 but at minimum within the following range: 0.15 m (internal diameter of pipe up to and including 1.0 m or for cables); 0.2 m (internal diameter of pipe above 1.0 m).

Lateral bedding shall be formed by spreading and compacting bedding material over the full width of the trench. Sufficient bedding material shall be provided to allow the pipes or cables to be worked into the bedding material and firmly supported to true line and level.

Sufficient space shall be left to enable the pipe joints to be made, tested and inspected and the Contractor shall ensure that at least three quarters of each pipe length is fully supported. Before any further filling the pipeline has been tested and approved by the Engineer. Pipe trenches shall be carefully filled with bedding material. Unless specified otherwise for the specific pipe types, all pipes shall be covered by bedding material to a level of 0.3 m above the top of the pipes. Unless specified otherwise for the specific cable types, all cables shall be covered by bedding material to a level of 0.2 m above the top of the cables.

The bedding material for plastic pipes (GRP, HDPE, and PVC) shall be according to the manufacturers’ requirements. [new]

The bedding material for concrete and steel pipes shall consist of sand-gravel, graded 0/25 mm.

The bedding material for cable conduits and cables shall consist of sand, graded 0/2 mm.

The remainder of the trench shall be back-filled with approved selected material in accordance with the Technical Requirements.

The difference in level of backfill on either side of pipes shall not exceed a maximum of 0.2 m. Backfill to structures shall generally be carried out as soon as practicable.

Embedding of pipes and cables includes for the supply of bedding material, preparation of the bed, placing of embedding layers (not more than 0.1 m compacted thickness) and compaction either by hand or with appropriate machines to the specified density below and around the pipes. The embedding works shall be carried out in compliance with DIN EN 1610.

### Stanks to Pipeline with Granular Bedding

When pipes are laid with granular bedding or backfill, a stank (which is an impermeable barrier designed to prevent groundwater flow along the trench) shall be provided across the full width of the trench and for the complete depth of the bedding. Fill between stanks shall not exceed 50 m intervals and shall be generally midway between manholes or thrust blocks.

Stanks shall be provided at any points where pipe trenches pass through or into impermeable strata whose permeability is lower than that of the adjacent ground so as to form a restriction to the flow of groundwater. In these cases, the stanks shall be formed so as to restore the continuity of the impermeable or low permeability, stratum where it has been intersected by the trench excavation.

The stank shall consist of:

* a 300 mm long plug of clay, clayey soil or other approved impermeable soil, or of a mixture of sand and bitumen, consolidated in an approved manner.
* a layer of plastic sheeting, minimum thickness 1 mm, cut to fit around the pipe across the full width of the trench and laid of the granular bedding or fill material at the natural repose angle.

All methods must form an impermeable barrier.

Bitumen shall not be used for trenches containing thermoplastic pipes.

The cost of providing stanks shall be included in the Contractor’s rates for pipe laying.

### Back-filling of Excavations for Structures

Compacted fill shall consist of approved material, spread and compacted in layers approximately horizontal and of uniform thickness with a slight outward slope and of a compacted depth not exceeding 0.2 m after compaction.

Soil lumps larger than 0.1 m in size shall be broken before compaction. The moisture content of the soil shall be carefully controlled either by the natural drying or wetting with a fine spray before filling.

Compaction shall be carried out by mechanical rollers, power rammers, vibro-tampers vibrating plate compactors or other approved plant so as to produce the specified density determined in accordance with DIN 18126 or such other minimum dry density as may be otherwise specified or ordered by the Engineer.

### Required Compaction for Various Fills

The natural ground over which filling is to be placed shall be cleared of all loose boulders, grass, productive soil, mud, bushes, trees, roots, other vegetation and other unsuitable material.

Unless otherwise specified, fill shall be spread by machine or manually in successive horizontal layers of not more than 200 mm loose depth and compacted to 95% Standard Proctor.

Operations on earthwork shall be suspended at any time when satisfactory results cannot be obtained because of rain, or other unsatisfactory field conditions. The Contractor shall drag, blade, or slope the embankment to provide proper surface drainage.

The material in the layers shall be of the proper moisture content before compaction. Wetting or drying of the material and manipulation when necessary to secure uniform moisture content throughout the layer may be required.

The Contractor shall take all necessary precautions to protect exposed faces against deterioration.

The Contractor shall compact the fill using approved compacting methods and equipment. Backfilling shall not impose uneven or excessive load on a structure.

All material used for filling shall be deposited and compacted as soon as practicable after excavation in layers of thickness appropriate to the compaction plant used. Filling of areas and embankments shall be built up evenly over the full width and shall be maintained at all times with a sufficient camber and a surface sufficiently even to enable surface water to drain readily from them.

Dry density of compacted fill 100% of the maximum dry density:

* Backfill for over-excavation,
* Final backfill of trenches under roads or railways,
* Backfill below structures.

Dry density of compacted fill 95% of the maximum dry density according to DIN 18126:

* Formation levels and pipe/cable bedding fills,
* Final backfill of trenches in general

Where required by the Engineer and before commencing filling, the Contractor shall at his own expense compact a trial area of filling of the type proposed using the equipment proposed for the works in accordance with specified standards of compaction. The area shall be of a size and depth to the approval of the Engineer sufficient for the trial to adequately represent the work involved in the general filling operations.

Variations of method or equipment will only be permitted when the Contractor demonstrates by field trials that the compaction obtained by the alternative method achieves compaction equivalent to that obtained by the approved method.

During the progress of the works the Contractor shall inform the Engineer of any factors outside his control which may adversely affect the compaction achieve so that the Engineer can give consideration to a variation of the equipment or method.

### Main Tests and Standards

The Contractor shall carry out all tests in accordance with ZTVE-STB in the latest edition or equivalent international standards. Soil compaction tests shall be carried out according to the relevant standards.

### Temporary Sheeting and Bracing

The Contractor shall be responsible for the design, installation, and maintenance during construction, and where appropriate, removal of all support works needed for trenches and other excavations (timbered walls with concrete or wood infill, sheet pile walls, etc.). The Contractor shall submit to the Engineer for approval, details of his proposal for excavation support which details shall include such drawings, calculations or other explanatory matter as the Engineer may require, but such approval shall not relieve the Contractor of his responsibilities under the Contract. No excavation work may proceed until the Engineer’s approval has been given to the Contractor’s proposals.

The Contractor shall not remove temporary works supporting the excavations until in the opinion of the Engineer the Permanent Work is sufficiently advanced to permit such removal which shall be executed under the personal supervision of a competent foreman. Where the removal of excavation support works is considered by the Engineer to endanger existing structures thus making them liable to subsidence damage, the Contractor shall leave such support works in place, removing only the minimum necessary to allow the reinstatement of the surfaces.

Works for pit sheeting and bracing close to private or public properties, structures and utilities shall be carried out with low vibration and low concussion.

### Levelling of Areas

Areas around or on top of structures shall be levelled to the required levels as indicated on the Drawings or instructed by the Engineer. The Contractor shall take due precautions to prevent any damage to the structures during the levelling. The levelling of areas around structures shall be carried out by approved methods. Any damaged item shall be replaced or repaired at the Contractor’s expense and to the satisfaction of the Engineer.

## Flood Protection

If new construction of structures or facilities are to be located in a floodplain, accepted flood proofing and other flood protection measures shall be applied to new construction or rehabilitation. To achieve flood protection, Contractors shall, wherever practicable, elevate structures above the base flood level rather than filling in land.

### Earth dikes

Dikes, if required, shall be high enough to prevent the 100-year flood from overtopping. Design requirements for earth dikes:

* Preconstruction surveys required for design
* Soil sampling and soil tests for dike embankment fill borrow areas
* Design of local drainage improvements (including culverts with flap gates and/or manual control gates).

### Mortared stone walls and slabs

Mortared stone walls and slabs shall be built at locations shown on Drawings, with the sections and stone sizes shown on the details.

Before the stones are placed, ground surface shall be arranged smooth and parallel to the finished surface considering the stone thickness and wall slope. Wall thickness shown on the Drawings or specified by the Engineer must be achieved with a single stone layer, and two stone layers on top of each other will not be accepted.

The void between the stones shall be filled completely with mortar, and stones shall be hammered after laying to get a strong bond between stones.

Larger stones shall be used at the edges of the stone surfaces, especially at the skirts of sloped surfaces. Stoned shall be laid from bottom to the top. Mortar, cement and water shall be in accordance with the Technical specifications: Concrete and Steel Works.

# Roadworks

## Standards

The Contractor shall carry out the works and provide materials described in this section in accordance with the appropriate standards. The main standards are, but are not limited by, the following:

DIN EN 1343 Kerbs of natural stone and concrete

DIN EN 13808 Bitumen and bituminous binders

DIN 18315 General technical specification for road construction: surfacing without binder

DIN 18316 General technical specification for road construction: surfacing with hydraulic binders

DIN 18317 General technical specification for road construction: asphalt surfacings

DIN 18318 General technical specification for road construction: Dry jointed sett and slab pavements, and surrounds

DIN 18354 General technical specification for road construction: asphalt flooring works

DIN EN 1342 Setts of natural stone for external paving - Requirements and test methods

DIN EN 13282 Hydraulic road binders

The Contractor may carry out the works or provide materials in accordance to local or other international standards (ISO and others), provided their requirements are superior or equivalent to the quality described in the above standards.

## General

The roadwork in this Contract comprise the construction of access and service roads at the site(s) (site roads) and include the reinstatement of existing surfaced public roads: The prices shall cover the cost of reinstating the roads which have been affected during the execution of the Works.

## General Road Layer Structure

### Top or Wearing Course

Top courses shall fulfil the following requirements in generally: good evenness, good grip, good sealing against lower layers against precipitation, low void content, high resistance against deformation:

* Minimum layer thickness: 3 cm (for bituminous wearing course) respectively 14 cm for concrete wearing course;
* Material: bituminous concrete, hot mix asphalt, asphalt mastic, concrete;
* Grading: 0/5, 0/8, 0/11, 0/16 (for bituminous wearing course).

### Binder Course

Binder courses shall fulfil the following requirements in generally: high resistance against deformation, good equalisation of unevenness of substratum, good shear acceptance:

* Minimum layer thickness of bituminous binders: 4 cm;
* Material: bituminous concrete with high void content;
* Grading for bituminous binders: 0/11, 0/16, 0/22.

### Base courses

Base courses shall fulfil the following requirements in generally: force distribution, frost proof:

* Minimum layer thickness: 8 cm;
* Material in case of bituminous binders and top layers: bituminous base course, hydraulically bound base course;
* Material in case of concrete top layers: hydraulically bound base course;
* Grading: 0/22, 032.

### Roads to be reinstated

The roads and pedestrian access pavements to be reinstated may include the following types of surfacing:

* Asphalt concrete pavement on a macadam base
* Asphalt concrete pavement on a cement stabilised gravel base
* Double bituminous surface treatment on a cement stabilised base
* Double bituminous surface treatment on a selected gravel base
* Natural cobblestones
* Gravel roads and foot paths
* Tiled pavements

For the precise details of materials to be used and thickness of construction, the Contractor shall refer to the Technical Requirements of the Local Road & Highway Authority and standards referred here in.

## Clearing and Grubbing

Clearing and grubbing for roadwork shall be executed in accordance with these Technical Requirements.

## Earthworks for Roads

The earthworks for roads shall generally be in accordance with these Technical Requirements.

The preparation of the subgrade includes the compaction of the subgrade, the grading of the formation and the removal of surplus materials.

Where the dry density of the natural ground underneath the formation level is below 95% of the maximum dry density as determined in DIN 18127 and CBR[[1]](#footnote-1) is lower than 5 the subgrade material shall be removed to a depth of 0.3 m and filled with a suitable material and shall be compacted to 95% of the maximum dry density.

The formation shall be graded to the levels, falls, cambers and densities as required and be kept free of standing water at all times.

Fill below 0.3 m depth under the formation level shall be compacted to 90% maximum dry density. Fill within 0.3 m depth of the formation level shall be compacted to 95% maximum dry density.

When compacting of subgrade sections particular attention shall be paid to the requirement that the natural subgrade or the fill shall be compacted with a slight outward slope to ensure good run-off of surface water.

Material excavated out of the road bed and which is suitable for fill shall be used for filling as far as this is practicable.

## Filling of Excavations beneath Site Roads and Public Roads

Excavations for pipelines and cables laid under site roads and public roads shall be backfilled with sand.

Filling shall be built up over the full width and compacted in layers not exceeding 0.2 m in depth at the optimum moisture content. The moisture content of the sand may require adjustment to attain maximum density. Sand, which contains insufficient moisture to obtain the desired compaction, will require the incorporation of additional water by the use of sprinklers and mixing before laying.

Layers more than 0.3 m below road formation shall be compacted to 90% of the maximum dry density determined according to DIN 18127. The Layers with less than a 0.30 m below road formation level shall be compacted to 95% of the maximum dry density determined according to the aforementioned standard methods.

The Contractor shall ensure that the sand laid immediately adjacent to a structure concrete wall or thrust block is well compacted. Hand operated vibrating plate compactors, vibro-tampers or power rammers shall be used. In other cases compaction shall be carried out by vibrating compactors, smooth wheel or pneumatic rollers of types approved by the Engineer.

Excavations for pipelines laid otherwise or for other structures beneath the carriage ways where mechanical compaction cannot be applied due to narrow space shall be back filled with lean mix concrete.

## Finish and Protection of Sub-Grade

When the sub-grade has been compacted to the required degree, the surface shall have a formation parallel to the finished surface of the carriage way and to the correct levels and cross-section.

The finished surface of the sub-grade shall be approved by the Engineer before any sub-grade material is placed. The sub-grade, once it has been finally compacted, shaped and approved, shall be protected and kept well drained.

Plant and materials shall not be stored or stockpiled on the formation. Contractor’s traffic shall not be permitted to pass over the completed sub-grade unless otherwise approved by the Engineer. The Contractor shall, at his own expense, repair any soft spots or damage caused to the sub-grade.

## Material and Construction of Sub-Base

The construction of sub-base includes the supply of graded mineral material, the laying, compaction and grading of the layer and the removal of surplus material.

The plant mix granular material used in the sub-base shall comply with the requirements specified in DIN 4226. All material shall be placed, spread evenly and compacted. Spreading shall be undertaken concurrently with placing. The material shall be spread in one or more layers, each not below 7.5 cm and not exceeding 15 cm, so that after compaction the total thickness is as required. The sub-base shall be laid to an accuracy of +1 / -2 cm.

Compaction of the sub-base shall be to 98% of the maximum dry density in accordance with DIN 18127 and shall be completed as soon as possible after the material has been spread. Where compacting plant is of insufficient capacity, the sub-base shall be laid in two or more layers. During the construction period the sub-base shall be maintained in such a condition that it will be drained at all times. The outflow shall be diverted away from the construction at all times.

Vibratory compacting plant may be used if approved by the Engineer. The number of passes to be made will be determined having regard to the characteristics of the plant to be employed and the material to be used.

If necessary, test specimens shall be taken to determine the optimum method of compaction. The surface of any layer of material shall, on completion of compaction, be well closed, free from movement under compaction plant and free from compaction planes.

All loose, segregated or otherwise defective areas shall be made good to the full thickness of the layer and re-compacted.

## Hydraulically Bound Base Course

In the case of base course constructed with cement bound granular material as base, the material to be used shall be naturally occurring gravel-sand, washed or processed granular material, crushed rock or any combination of these, provided that the sulphate content shall not exceed 1%. The material shall be sufficiently well graded to ensure a well closed surface finish and have a grading within the range as in DIN 4226 or as otherwise approved by the Engineer.

To provide a crushing strength, the granular material shall be mixed with ordinary Portland cement in a weight batch mixer or similar approved. When batch mixers are used the mixing time per batch shall be not less than one minute, unless a shorter time is permitted by the Engineer after preliminary trial mixing. If continuous mixing is used, the rate of feed of materials shall be adjusted to give a consistent mixture. If a water rose is used for adding the water into the mixer, the rate of flow shall be adjusted to give uniformity in moisture content throughout the mix. The moisture content of the mixed material shall not be more than 2% above the optimum.

The material shall be placed and spread evenly; spreading shall be undertaken concurrently with placing. Road base material shall preferably be spread in one layer using a paving machine or similar approved. The material shall be spread so that after compaction, the total thickness is as required. The Contractor shall organise the work in such a way that longitudinal joints against hardened material are avoided as far as possible. If this is not possible then before work proceeds against a longitudinal joint of hardened material, the edge compacted previously shall, if it had been exposed for more than an hour, be cut back vertically to produce a face equivalent to the specified thickness of the layer of properly compacted material.

Compaction of the road base to a minimum of 98% of the maximum dry density shall be completed as soon as possible after the material has been spread. Compaction equipment shall not bear directly on hardened or partially hardened material previously laid other than what is necessary for achieving the specified com­paction of the joint. Special care shall be taken to obtain full compaction in the vici­nity of both longitudinal and transverse joints, and the Contractor shall use special small compactors in addition if necessary or instructed by the Engineer.

Any loose or poorly compacted material in the vicinity of construction joints shall be removed and replaced with fresh material. The surface of any layer of material shall on completion of compaction be well closed, free from movement under compaction plant and free from compaction planes, ridges, cracks or loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of the layer and re-compacted. If this cannot be done within 2 hours of mixing, the making good shall comprise the material being broken out to the full thickness of the layer, removed and replaced with freshly mixed material compacted according to the Specification.

The base course shall, immediately on completion of compaction, be cured for a period of at least 7 days, unless otherwise approved by the Engineer. Curing shall be achieved either by covering with approved impermeable plastic sheeting adequately secured from being blown off the surface with joints overlapped at least 0.3 m and set to prevent egress of moisture or in accordance with Clauses in this Specification dealing with concrete or by spraying with an approved curing compound. Notwithstanding the above the Contractor shall construct the base course in accordance with the requirements and specification of the relevant Highway Authority or Municipality. The Specification included herein shall be adopted only in the absence of any particular requirements from these authorities.

## Temporary Reinstatement of Public Roads

Temporary reinstatement of public roads shall be carried out as soon as is practical after completion of the Permanent Works and before the section of the road or pavement is re-opened for public use. Temporary reinstatement shall be maintained by making good any subsidence, shrinkage, defect, imperfection or fault a period as directed by the Engineer but at least 3 months prior to final reinstatement.

Temporary reinstatement where not specifically required by the General Directorate of Roads or the Municipality shall comprise an additional depth of sub-base material as instructed by the Engineer. Original surface materials may be placed by hand with the wearing course upper most. The method of placing and compacting of temporary reinstatement shall be similar to that for road base construction, to the same surface tolerance, and to suit levels of the surrounding undisturbed road or pavement.

Only materials approved by the Engineer shall be used for making good any defects.

Immediately prior to final reinstatement, the temporary reinstatement shall be cut out and disposed of off-site and the road base cut out where found to be damaged or otherwise defective and replaced and compacted as specified.

## Asphalt Pavements

The laying of top bituminous layers, binders and base course shall include the supply of ready mix bituminous material, the placing and compaction of the bituminous material and the removal of surplus material. [new]

The final re-surfacing of asphalt public roads and pavements are included in the rates and prices.

The Contractor shall when laying the temporary reinstatement ensure that levels of manholes and surface boxes shall match the final road surface level.

Asphalt roads within the site(s) shall be surfaced in accordance with these Technical Requirements.

All the tests required by the requirements of competent Road Authority shall be carried out.

### Bituminous Works

Bituminous mixture shall be manufactured until a job-mix formula has been submitted by the Contractor and approved by the Engineer in writing.

The formula shall indicate the exact percentage of each sieve fraction and the exact percentage of bitumen to be used in the mixtures, including the mix temperature. The laying of levels shall include the supply of bituminous material in a quality corresponding to ZTVA-STB, the placing and compaction of the bituminous layer with appropriate machines and the removal of surplus material.

### Weather Limitations

Bituminous courses shall be constructed only when the base is dry and when the weather is not rainy. Such courses shall not be constructed when the atmospheric temperature is below 10°C and falling, but may be constructed when the atmospheric temperature is at least 8°C and rising, unless otherwise directed by the Engineer.

### Preparation

Immediately before applying a bituminous pavement, the surface of the underlying course shall be thoroughly cleaned of all loose or foreign material. The underlying layer shall be coated with a tack-coat of the liquid asphalt rapid curing type. (RC-250). The tack-coat to be used shall be to the Engineer’s approval. The tack-coat shall be applied just sufficiently in advance of the placement of the bituminous top layer asphalt concrete mixture so as to provide a thin adhesive film of bituminous cement to ensure a good bond. Tack-coat shall be asphalt emulsion (50% water, 50% bitumen).

The tack-coat shall be uniformly applied by means of a pressure hand spray, in quantities of 0.3 l/m2 of surface, unless otherwise directed by the Engineer. Stakes for alignment control shall be furnished, set and maintained by the Contractor, subject to checking and correction by the Engineer, in order that the works shall conform to the lines shown on the Drawings.

The stakes shall be set in lines parallel with the centre line of the area to be paved, offset and spaced, as directed by the Engineer.

Asphalt at the plant shall have min. 150°C just before the delivery.

### Transportation

All bituminous mixtures shall be transported from the mixing plant to the spreader in trucks having tight, clean, smooth beds which have been oiled with a minimum amount of approved thin oil to prevent adhesion of the mixtures to the trucks. Each load shall be covered with canvas, or other suitable material, to protect it from dust or rain, and to prevent the loss of heat. Deliveries shall be arranged so that spreading and rolling of all the mixtures prepared for a day’s run can be completed during daylight, unless artificial light satisfactory to the Engineeris provided. Any excessively wet loads will be rejected. Hauling over freshly laid material will not be permitted.

### Placing

The asphalt pavement shall be constructed in accordance with the thickness as present prior to removal and excavation work or as shown on the Drawings with a minimum thickness as specified. The temperature of each mixture when dumped into the spreader shall be as directed by the Engineer, plus or minus 10°C. Asphalt mixture shall have a minimum of 90°C.

The spreader shall be adjusted and the speed regulated, so that the surface of the course will be smooth and of such depth that, when compacted, it will conform to the cross section shown on the Drawings. The length of any lane before placing the adjacent lane shall be as directed by the Engineer. Where two spreading machines are operating in staggered position, no single lane shall be laid in advance of the adjoining lane further than will permit a satisfactory hot longitudinal joint between the lanes.

Where forming a hot longitudinal joint, the 150 mm strip along the edge against which additional material is to be laid shall not be rolled until such additional material is placed, except when the work is to be discontinued. After the first lane has been placed and rolled, the adjacent lane shall be placed while the unrolled 150 mm strip is hot and in readily compatible condition. Rolling of the adjacent lane shall begin along the joint. Placing of the mixture shall be as continuous as possible.

Rolling shall be carried out using at least two machines, one three wheel roller having a weight of 10 t, and the other rubber wheel roller having a weight of 20 t.

In areas where the use of machine spreading is impractical, the mixture may be spread by hand and dressed with rakes. The loads shall not be dumped any faster than can be properly handled by the shovellers and rakers.

Contact surfaces of previously constructed pavement kerbs, manholes and similar structures shall be painted with a thin tack-coat prior to placing the bituminous mixture.

### Compaction of Mixtures

Compaction shall be effected by three-wheel rollers and tandem rollers.

Rolling of the mixture shall begin as soon as after placing as the mixture will bear the roller without undue displacement. Delays in rolling freshly spread mixtures will not be permitted. Initial rolling shall be effected by tandem rollers, followed immediately by the three-wheel rollers. Rolling shall start at the extreme sides of the lanes and proceed toward the centre of the pavement, overlapping on successive strips by at least one-half the width of the rear wheel of the three-wheel roller. On the super-elevant curves, rolling shall begin at the low side and progress toward the high side. Alternative trips of the roller shall be slightly different lengths. Tests for conformity with the smoothness will be made immediately after initial compaction, any deviations in excess of the specified tolerances shall be corrected by loosening the hot surface with rakes and removing or adding material as directed before continuing the rolling.

Generally, rolling shall be executed in such a manner as to produce a smooth surface and shall be continued until a density of at least 100% has been obtained.

During rolling, the wheels of the rollers shall be moistened to prevent adhesion of the mixture to the wheels, but an excess of water will not be permitted. The Contractor shall furnish additional and sufficient rollers if it is found that the pavement density specified is not obtained. In all spaces not accessible to the roller, the mixture shall be thoroughly compacted with hot hand tampers weighing not less than 10 kg, with a tamping face of not more than 300 cm². Skin patching of an area that has been rolled will not be permitted.

* Any mixture that becomes mixed with foreign material, or is in any way defective, shall be removed, replaced with fresh mixture and re-compacted.
* The rollers shall not be permitted to stand on pavement which has not been fully compacted.
* All Necessary matters on the pavement, either when the rollers are in operation or standing are forbidden to stay on fresh asphalt layer.
* The Contractor shall provide competent workmen who are capable of performing all work, incidental to the correction of all pavement irregularities.

The finished surface not varies more than 3 mm when tested with a 3.0 m straight edge applied parallel with the centre line of the pavement. After completion of the final rolling, the smoothness of the course will be checked, and any irregularities that exceed the tolerance or that retain water on the surface, shall be corrected by removing the defective area and replacing with new pavement. The completed bituminous pavement will be tested for thickness at such intervals as directed by the Engineer. Where the thickness proves to be more than 5 mm smaller than the specified pavement thickness, the deficient pavement shall be removed and replaced with satisfactory pavement with no additional payment.

All joints shall present the same texture, density and smoothness as other areas of the course. The joints between old and new lanes, or sections shall be carefully made in such manner as to ensure a continuous bond between the old and new pavement. All trimmed contact surfaces of previously constructed pavement shall be painted with a thin, uniform tack coat before the fresh mixture is placed. When the edges of joints are irregular, honeycombed, or poorly compacted, all unsatisfactory sections of joint shall be trimmed to expose an even, vertical, or sharply sloping surface for the full thickness of the course. Fresh mixture shall be raked uniformly against the joint, followed by rolling, no vehicular traffic of any kind shall be permitted on the pavement for at least 24 hours.

## Concrete Pavements

### General

Cast-in situ concrete pavements shall be constructed of concrete in the required thickness of class C20/25 or better according to EC 2 / EN 1992reinforced with steel mesh or steel bars according to the static calculations. The concrete shall be placed on a sub-base consisting of 50 mm rammed lean mix concrete or a PVC foil with a minimum thickness of 0.2 mm. The concrete, its placing and curing shall otherwise conform to these Technical’s Requirements.

### Joints

The joints shall in generally conform to the Technical Requirements.

Joint intervals, structure, tapes, filler, sealer, dowels, and anchors shall be approved by the Engineer before any joint construction.

### Dummy Joints

Cutting of joints shall take place as soon as possible in order to avoid uncontrolled crack formation. However, sufficient strength of the concrete shall be considered to avoid rupture at joint faces. Trimming of joints and chamfering of joint edges for joint filling shall be carried out after the concrete has reached the final strength. To protect the joint notch, padding shall be inlaid.

### Expansion Joints

Transverse expansion joints shall be installed at 8 m intervals. A longitudinal expansion joint shall be installed along the centreline. The joints shall be formed with a soft wooden plank of thickness 20 mm. If required by the Engineer or the Highway Authority, the Contractor shall remove the timber insert and fill the space with joint filler and sealer or tapes. The space shall be thoroughly cleaned prior to filling and sealing respectively applying tapes.

Joint dowels and anchors have to be protected in the middle against corrosion by appropriate coating.

### Pavements with Cobblestones

The execution for sub-grade material and the sub-base shall be in accordance with the relevant Clauses in this Specification. The cobblestones shall be laid evenly according to the lines and levels of the adjacent pavement. All stones shall be firmly bedded on the underlying course and shall be laid against each other. Upon completion the pavement, sand shall be strewed, and be compacted with a mechanical vibrating machine of sufficient weight.

### Side Walks Pavements

Sidewalks shall be paved either with

* Pre-cast concrete pavers of a colour approved by the Engineer with a minimum thickness of 5 cm to be laid on a sub-base of 3 cm of sand over 10 cm of good quality material levelled and compacted;
* Pre-cast concrete paving flags with a colour approved by the Engineer with a minimum thickness of 3 cm to be laid on a sub-base consisting of 5 cm of lean mix concrete over 10 cm of good quality material levelled and compacted;
* Natural stones to be laid on a sub-base of 5 cm of sand. Natural stones shall be sound, durable, hard, and have such properties that they will not disintegrate from the action of weather in handling and placing. The density of stones shall be not less than 2.2 t/m³ and their size range between 15 and 20 cm.

The pavement shall be laid evenly according to the lines and levels of the adjacent pavement. All tiles or stones shall be of approved type, design and make and shall be firmly bedded on the underlying course and shall be laid against each other. Upon completion of the tiling sand shall be strewed.

## Drainage

Surface water shall be drained from sloped road surfaces to a drainage system of open trenches or pipes conveying the surface water into the river by gravity.

The works for road drainage shall include the supply, installation, laying, construction of gullies, slop hoppers, gutters, pipes, trenches, manholes, etc. including discharge building.

Where practicable drainage work shall be completed before road works are commenced.

Prefabricated concrete or cast iron gullies (including grating), slop hoppers, drainage gutters (including grid covers) shall be of sufficient strength to withstand the designed traffic loads and shall be approved by the Engineer before installation.

Trenches for piped drainage shall be excavated to the minimum dimensions necessary for the proper construction of the Works, and after pipes have been laid, tested and, where specified, surrounded with gravel or concrete, the trenches shall be backfilled with excavated material and compacted to a dry density equal to that of the adjacent ground. Surplus excavated material shall be disposed of off -site.

Pipes shall be laid to lines and levels shown on the drawings. Where directed by the Engineer, pipes shall be surrounded with concrete as detailed on the drawings.

Porous pipes shall be laid dry-jointed and shall be surrounded with gravel as detailed on the drawings.

Pipe laying and pipes shall in generally conform to these Technical requirements.

### Open Drainage Channels

Open drainage channels for roadwork shall be constructed as earth channels with a width up to 1.0 m and a depth up to 0.5 m. The bottom of the trench and the lower part of the slopes (1/3 of the total depth) shall receive rip-rap as described below. The works to be carried out shall include the required excavation, the trimming, compaction and pitching of surfaces and site clearance after completion of the works.

### Rip-Rap

Plain rip rap shall consist of quarry run stone, or field stone, or broken concrete. A filter fabric shall be placed under plain rip rap. The stone shall be graded so that the smaller stones are uniformly distributed throughout the mass.

The Contractor may place the stones by mechanical methods, augmented by hand placing where necessary, provided that when the rip rap is completed it forms a properly graded, dense, neat layer of stone. The completed rip rap shall be at least the thickness indicated on the plans.

### Filter Fabric

Surfaces to receive filter fabric shall be graded to the lines and grades shown on the plans, unless otherwise directed by the Engineer. The surface shall be free of obstructions, debris, and pockets of soft or low density material.

At the time of installation, the fabric will be rejected if it has defects, rips, holes, flaws, deterioration, or damage incurred during manufacture, transportation, or storage.

The fabric shall be laid smooth and free from tension, stress, folds, wrinkles, or creases. Horizontal overlaps shall be a minimum of 30 cm with the upper fabric overlapping the lower fabric. Vertical overlaps shall be a minimum of 50 cm with the upstream fabric overlapping the downstream fabric. In the event that the fabric is displaced or damaged during rip rap placement, the rip rap shall be removed and the fabric repositioned or replaced prior to replacement of the rip rap, all at no additional cost to the Technical.

The placement of the fabric and rip rap shall be performed in a continuous manner as directed by the Engineer. The fabric shall be protected from damage due to the placement of rip rap or other materials limiting the height of drop of the material or by placing a cushioning layer of sand on top of the fabric before dumping the material.

## Kerb Laying

The laying of kerbs shall include the supply of kerbs, straight and for curvature, the concrete foundation and the bedding in mortar including cutting of kerbs and removal of debris. [new]

Precast concrete kerbs shall be laid to the relevant national Standards, true to line and level and any kerb found to be more than 1 cm out line of line level at either end shall be lifted and re-laid.

Where practicable, kerbs shall be laid before paving. In reinstatement the original kerbs shall generally be re-used except where these are damaged. They shall be thoroughly cleaned before replacement and laid to suit the line and level of the undisturbed kerbs.

Kerbs laid on stabilised pavement shall be bedded on a layer of 2:1 sand-cement mortar 15 cm thick and shall be backed with concrete, cast over and around steel dowels previously driven into the green pavement material and shaped up to the required cross section.

Kerbs laid otherwise than on concrete pavement shall be bedded on a layer of 2:1 sand-cement mortar 15 cm thick and shall be backed with concrete shaped up to the required cross-section.

Specially cast circular kerbs shall be used on curves of 13 m radius or less.

Kerbs shall be jointed with cement mortar except at expansion joints which shall be made with performed joint filler 13 mm thick. Expansion joints shall be carried trough the concrete backing and foundation.

## Gravel Roads

Gravel roads will only be constructed upon direction of the Engineer. The material for gravel roads shall be natural or crushed well graded gravel with a maximum grading of 32 mm. The compacted gravel bed shall be laid on the prepared road base and have a thickness of not less than 15 cm.

## Road Markings

Where shown on the drawings or directed by the Engineer, the Contractor shall paint markings on the completed road surfaces.

Before paint is applied, the road surface shall be thoroughly cleaned and dried to remove all dust and other deleterious matter.

Except where otherwise specified all lines shall be 10 cm wide. All lines shall be pre-marked with dots at approximately 3 m centres on straight lines and 1 m centres on curves. Lines on curves shall not be formed by a series of straight sections around the curve. The alignment shall not deviate more than 2 cm in 25 m. The width of the lines shall not be varied more than plus or minus 6 mm from the specified width.

The paint shall be applied with due regard to the manufacturer’s instructions. Lines and other road markings shall be applied uniformly and shall have sharply defined edges without runs or spatters.

## Concrete Bollards

Concrete bollards shall be pre-cast and sized 1.0 m x 0.4 m x 0.4 m. Exposed surfaces shall be left smooth and fair-faced from the shutter. The top surface shall be weathered to falls. Surfaces below ground shall be left from the shutter or hacked to provide a key with the encasing concrete.

Bollards shall be set to project 55 cm above ground level and be vertical, true and plumb.

The base of each bollard shall be encased in mass concrete to a depth of 60 cm and all round to a thickness of 20 cm except where placed adjacent to building plinths or other structures. In such cases the concrete shall fill the gap between the structure and bollard.

A sample bollard shall be cast and submitted to the Engineer for approval.

## Testing

The Contractor shall carry out tests at such intervals as the Engineer may direct to demonstrate that the materials for the granular sub-base and road-base comply with the Technical Requirements and that the specified density for the sub-grade, sub-base and road-base are being achieved.

The Contractor shall inspect and test each area of layer for compliance with surface level accuracy.

## 

# Concrete

## Standards

The Contractor shall carry out the works described in accordance with the appropriate standards or equivalent local or international standards.

The list of International standards by type is given below:

##### Classes of Concrete

The classes of concrete strength to be used in the works are the following:

Class of concrete (nominal test cylinder diameter 15 cm, height 30 cm / cube 15 cm x 15 cm x 15 cm strength, each 28 days after mixing), according to EN 206 – 1.

##### Loading Assumptions

EN 1992(EC[[2]](#footnote-2) 2) Design of concrete structures

##### Cement

EN 197-2 Cement

##### Aggregates

EN 12620 Aggregates for concrete

EN 13055 Lightweight aggregate for concrete, mortar, grout, bituminous mixtures, surface treatments and for unbound and bound applications

##### Water for Concrete

EN 1008 Mixing water for concrete – Specification for sampling, testing and assessing the suitability of water

##### Concrete

EN1536 Bored piles

EN 1992(EC 2) Design of concrete structures

DIN 1048 Testing concrete

DIN 4126 Stability analyses of diaphragm walls

DIN 4235 Concrete compacting

EN 450-1 Fly ash for concrete

EN 206-1 Concrete characteristics, production, conformity

##### Quality Control

EN 12350 Testing of fresh concrete

EN 12390 Testing of hardened concrete

DIN 52170 Determination of composition of hardened concrete

ISO 15148 Determination of water absorption coefficient

ISO 1920 Testing of concrete

ISO 4103 Classification of concrete consistency

##### Concrete Repair

EN 1504/1542 Products and systems for concrete repair

EN 1799/1877 Products and systems for concrete repair

EN 12190 Compression strength of repair mortars

##### Admixtures / Additives

EN 480/934 Concrete admixtures

##### Alkali-Silica Test Methods

ASTM C 227 Standard test method for potential alkali-silica reactivity of cement-aggregate combinations (mortar-bar method)

ASTM C 289 Standard test method for potential alkali-silica reactivity of aggregates (chemical method)

ASTM C 1260 Standard test method for potential alkali-silica reactivity of aggregates combinations (mortar-bar method)

## Design Concrete Requirements

### Concrete Classes

The different classes of concrete shall be used as follows:

|  |  |
| --- | --- |
| C8/10 | for plain concrete only for fill in trenches, for blinding and for screed |
| C12/15 | for plain and reinforced concrete for screed and encasements |
| C20/25 | for reinforced concrete in civil structures not in contact with water, wastewater, sludge, for reinforced concrete for thrust blocks, etc. |
| C30/37 | for watertight reinforced concrete in contact with water, wastewater, sludge, etc., and where especially directed by the Engineer. |
| C35/45 | for precast concrete structures |
| C45/55 | for pre-stressed precast concrete structures |

### Crack Control under Working Load

Concrete structures shall be designed, reinforced and poured and cured to limit crack width under working load:

* The maximum allowed crack width is 0.1 mm in the service ability limit state (structures filled with water to maximum design water level and with soil back-filled if any. The ground water level and the pressure from the surrounding soil should in this state be stipulated with low values).
* Even though the crack widths normally are calculated in the serviceability limit state only, the maximum allowed crack width is 0.3 mm in a state where structures either are filled with water without any surrounding soil or structures are empty only taking the full pressure from the soil and ground water.
* The partial safety factor, γf, for water pressure shall be 1.0 and for earth pressure 1.4 in this state.
* Where the external restraint factor R is greater than zero, a minimum amount of reinforcement for reduction of crack widths shall be placed.
* For concrete water or sludge tanks, the minimum concrete pressure zone either inside or outside face of the wall shall be 5 cm, or, if aggregate is used with a grain size >32 mm: max. aggregate grain size +2 cm.
* In order to incorporate the effects from thermal action, shrinkage and creep the Contractor should make the construction joints in accordance with the approved Drawings. No other joints will be allowed. The Contractor shall make his structural documentation in accordance with this layout.

### Minimum Member Thickness

For water or sludge retaining structures, all concrete members (slab, wall) must have a minimum thickness of 30 cm.

## Organisation of Concrete Production at the Site

At the commencement of the Contract the Contractor shall submit for the approval of the Engineer Method Statement detailing his proposals for the organisation of concreting activities at the site. The concrete production plant shall preferably placed at the site.

The Method Statement shall include the following items:

1. Plant proposed and layout of concrete production facility.
2. Proposed method of organisation of the concrete production facility.
3. Quality control procedures for concrete and concrete materials.
4. Transport and placing of concrete.
5. Details of formwork including striking times and procedure for temporary support of beams and slabs.
6. Protection and curing.

## Ready Mix Concrete

Concrete obtained from a single supplier of ready-mix concrete may be used in the Works subject to the written approval of the Engineer. Such approval will not be given until the Engineer is satisfied that the organisation and control of the manufacture and delivery of all ready-mix concrete is in accordance with the Technical Requirements.

## Materials and Testing

### Type of Cement

The type of cement used in the Works shall be cement from a single approved source conforming to the requirements of Portland cement in accordance with EN 197-1.

The Contractor shall analyze the groundwater in the project area in accordance with EN 1008. If the groundwater is found to have aggressive effect on concrete, then the concrete used in structures in contact with groundwater shall be made with sulphate-resisting cement.

Sulphate-resisting cement shall be used for infrastructure works and structures exposed to wastewater and sludge as specified in EN 197-1. The cement shall either be delivered in sealed bags marked with the manufacturer’s name or in bulk consignments in a manner approved by the Engineer.

### Tests of Cement

Before any cement is ordered in quantity or delivered to the Site, the Contractor shall submit to the Engineer for his approval a detailed list of the sources, country or countries of origin and manufacturer’s brand names of the types of cement which he proposes to use.

The Contractor shall submit to the Engineer, free of charge, test certificates relating to each consignment of cement. Each certificate shall show that a sample of the consignment has been tested by the manufacturer or by an approved laboratory and that it complies in all respects with the requirements of the Technical Requirements.

When required by the Engineer, the Contractor shall supply samples of cement taken on delivery to site, or during storage on the site, for testing at a nominated laboratory free of charge.

No cement from any consignment shall be used without the approval of the Engineer and the Contractor shall maintain a record of the locations of the concrete made from each consignment which record shall be available for inspection by the Engineer.

If for any reason the Contractor shall decide to vary the source of supply, country or manufacture in respect of any type of cement already approved by the Engineer at any time during the Contract, than he shall give adequate notice of every such variation to the Engineer. The Contractor shall carry out all the tests called for by the Engineer’s written approval of such variation before ordering any material from the new source or supplier.

If cement has been stored on the site for more than 40 days or in the opinion of the Engineer is of doubtful quality, new tests may be required, at the Contractor’s expense, to check whether the cement is still conforming to the requirements.

### Delivery and Storage of Cement

All cement shall be delivered to the site in properly and permanently marked, sound and sealed bags or other approved containers, unless written approval from the Engineer is obtained for the hanging of cement in bulk.

Cement shall be delivered in quantities sufficient to ensure the proper progress of the Works and the quantities held in stock on site shall be to the approval of the Engineer. Such approval shall not in any way relieve the Contractor of his responsibilities for providing cement. Cement from abroad, shall be packed in sealed plastic bags and placed inside paper bags.

Cement when being conveyed to the site in trucks or other vehicles, shall be adequately protected from the weather and from contamination by dust, sand or any organic materials. Any cement, which shall prove to have been exposed to damage by water, will be rejected upon delivery.

All cement shall be stored in a weatherproof and reasonably airtight building provided solely to that purpose. The floors of the building shall be raised at least 30 cm above the ground level to prevent the absorption of moisture.

Storage of cement in the open may be permitted on small works on the written authority of the Engineer, in which case the cement shall be placed on a raised platform and amply protected by waterproof coverings to the approval of the Engineer. It is not permitted to store bags to a greater height than 2 m. In the case of delivery of cement in bulk, the cement shall be stored in a properly designed silo. The silo shall be waterproof and must be provided with walls properly insulated against sunlight.

Where silos are used for the storage of cement each silo or compartment thereof shall be completely separate and fitted with a filter or an approved alternative method of dust control. Each filter for dust control system shall be of sufficient size to allow delivery of cement to be maintained to prevent undue emission of dust and to prevent interference with weighing accuracy by build-up of pressure. The Engineer shall be furnished with the means of identifying the several consignments of cement delivered. Each consignment of cement shall be stored separately so as to provide easy access for inspection and testing.

After they have been approved by the Engineer, consignments shall be used in the order in which they were delivered. No cement shall be taken from the storage unless it is needed for immediate use.

### Cement Measured by Weight

All cement used in the Works shall be measured by weight. Cement from partly filled or unsealed bags shall not be used.

### Rejection of Cement

Notwithstanding the receipt of the test certificate and the approval of the Engineer, the Engineer may reject any cement as a result of further tests. The Engineer may also reject cement, which has deteriorated as a result of inadequate protection or other causes or in any other case where the cement is not to his satisfaction. The Contractor shall remove all rejected cement from the site without delay at his own expense.

### Quality of Water

Water for use in concrete, mortar mixing and curing shall be obtained from an approved source and shall be of a quality that will not affect the setting time, strength, durability of the concrete or mortar, or the appearance of hardened concrete or mortar by discolouration or efflorescence, or the reinforcement at any age of the concrete or mortar.

Water shall be clean, potable, blended or unblended, with a pH between 5.0 and 9.0 and shall be tested in accordance with EN 1008. The following limits shall not be exceeded:

* Total dissolved solids (TDS) not greater than 2000 ppm
* Suspended solids not greater than 2000 ppm
* Chlorides (Cl) not greater than 500 ppm
* Sulphates (SO4) not greater than 1000 ppm
* Alkali (HCO3/CO3) not greater than 1000 ppm.

Water shall be stored in approved, clean containers which are protected from sun, wind, dust, organic contamination or from contamination by any other source.

### Fine and Coarse Aggregates

Fine and coarse aggregates for concrete shall be obtained from sources approved by the Engineer. Fine aggregates shall consist of natural sand unless otherwise approved.

Aggregates for all types of concrete shall be from natural sources. They shall be hard, strong and durable and shall not contain harmful material of sufficient quantity to affect adversely the strength or durability of the concrete or, in the case of reinforced concrete, to attack the reinforcement. The aggregates shall be obtained from an approved source and shall conform to the requirements of EN 12620.

Fine and coarse aggregates shall comply with the following chemical requirements.

* 1. Fine and coarse aggregates shall not contain more than 0.10% and 0.05% by weight of chlorides (as NaCl).
  2. Fine and coarse aggregates shall not contain more than 0.40% by weight of acid soluble sulphates (as SO3).
  3. Coarse aggregates shall be a minimum of 85% by weight calcium carbonate.
  4. Fine and coarse aggregates shall not be potentially reactive with alkalis.
  5. Fine and coarse aggregates in concrete elements exposed to wastewater shall be equivalent to the high sulphate resistance of the cement. Appropriate aggregates are siliceous sand and gravel. In order to provide maximum quality of concrete exposed to wastewater it is strongly recommended to use micro-silica in the concrete mix.

If this requirement cannot be met the Contractor shall adopt constituents for his concrete such that either:

* the cement material shall have a reactive alkali content not exceeding a maximum value of 0.6% by mass when defined and tested in accordance with the method prescribed, or
* the total mass of reactive alkali in the concrete mix shall not exceed 3 kg per m3 of concrete when defined, tested and calculated in accordance with the method prescribed.
* the methods prescribed for complying with (1) and (2) above shall be those set out in ASTM C 227, ASTM C 289, and ASTM C 1260.

The Contractor shall notify the Engineer of his proposals for complying with this requirement at the time of commencement of the Works.

If, in the opinion of the Engineer, the aggregates fail to comply with, or if there are doubts as to the uniformity of their compliance with the specified purity requirements, he will order all aggregates to be washed before use in the Works. When washing is ordered, it shall be done by using water of the quality specified herein and using methods and plant approved in advance by the Engineer and all costs arising there from shall be borne by the Contractor.

Each size of fine and coarse aggregate shall be stored in separate bins or on areas covered with steel plate, concrete or other hard and clean surface, which shall be self draining and protected from contamination by earth or other deleterious matter.

Fine and coarse aggregates shall be stored in such a way so as to avoid the two materials from becoming intermixed.

### Grading of Aggregates

The grading of ~~fine~~ aggregates shall comply with EN 12620. The Contractor’s attention is drawn to the fact that it may be necessary to combine two or more fine aggregates, or remove some fractions by hydraulic classification, in order to achieve the grading as necessary.

The maximum size of aggregates required will not normally exceed 32 mm. At least five ~~four~~ separate size ranges of aggregate required as follows:

* Fine aggregate: 0/2 mm
* Fine aggregate: 2/4 mm
* Medium coarse aggregate grading nominal size: 2/8 mm
* Medium aggregate: 8/16 mm
* Coarse aggregate: nominal size: 16/32 mm
* Coarse aggregate:~~:~~ 32/45 mm mass concrete

### Storage of Aggregates

Each size of fine and coarse aggregate shall be stored in separate bins or on areas covered with steel plate, concrete other hard and clean surface, which shall be self draining and protected from contamination by earth or other deleterious matter.

Fine and coarse aggregates shall be stored in such a way so as to avoid the two materials from becoming intermixed.

### Tests on Aggregates

The Contractor shall submit to the Engineer samples of the fine and coarse aggregates proposed for use in the Works. Samples shall be of a size sufficient to carry out all preliminary tests specified which the Engineer may order in addition to the concrete tests specified in these Technical Requirements. The Contractor shall provide the 50 kg sample for comparison purposes described below. The samples shall then be tested in the presence of the Engineer by the Contractor in accordance with the Technical Requirements or as the Engineer may direct.

If the source of aggregates is changed at the Contractor’s request and with the approval of the Engineer at any time during the course of the Works, all sampling and testing described in the relevant Sections shall be repeated at the Contractor’s expense.

After approval has been given for any particular aggregate, a sample weighing at least 50 kg of the approved aggregate shall be retained by the Engineer as a standard against which all future samples shall be compared.

During the course of the Contract, fine and coarse aggregates shall be tested at site as often as required by the Engineer and at the Contractors expense.

### Admixtures and Additions

Where required or approved by the Engineer, the Contractor shall use admixtures such as plasticizer, retardants and/or additives such as pigments in the concrete. Proportioning and mixing of admixtures / additives thereof to be used in the concrete shall be in accordance with manufacturer’s recommendations and subject to the Engineer’s approval.

Admixtures / additives shall only be those covered by valid test mark and shall only be used under the conditions stipulated in the test certificates.

No admixtures / additives shall have any adverse effect on the concrete in particular the strength or durability of the concrete or the corrosion protection of the reinforcement.

Admixtures / additives shall be added to the batch in solution in a proportion of the mixing water according to the manufacturer instructions. This solution shall be batched in such a manner that will ensure uniform distribution of the additives throughout the batch during the specified mixing period.

Admixtures / additives shall be suitable for use in contact with potable water after 30 days of concrete curing.

All admixtures / additives shall satisfy the requirements of the respective standards.

### Delivery of Samples

Samples of cement, water and fine and coarse aggregates called for in the foregoing sections shall be delivered to the Engineer for testing by the Contractor before concreting. Cube tests shall be completed before work is due to start.

## Concrete Mixing and Testing

### Proportions of Materials

The proportions of cement, fine and coarse aggregates and water proposed by the Contractor for the use in the Works shall be determined in accordance with the requirements set in EN 1992 for each class of concrete and shall be approved by the Engineer as a result of satisfactory preliminary tests made in accordance with the Technical Requirements.

### Water-Cement Ratio and Compressive Strength

The minimum compressive strength and cement content shall be not less than required in the appropriate DIN standard. If necessary to obtain the required strength, the Engineer may order the cement content of any class to be in­creased over the quantity specified in the standard. The Contractor shall furnish such increased quantities of cement at no additional cost to the Contracting Authority, if so ordered. The maximum water-cement ratio shall be less than 55 kg of water per 100 kg of cement.

### Limits of Salt Contents

All concrete mixes shall contain less than 0.6% total chlorides (as chloride ions) and less than 4.0% total acid soluble sulphate (as sulphite ions). Tests shall be carried out in accordance with the appropriate DIN standard.

### Consistency

The quantity of water added to a batch of concrete shall be in accordance with EN 1992, just sufficient to produce a concrete which in the judgement of the Engineer can be placed properly without segregation and which can be compacted by vibration to give the desired density, impermeability and smoothness of surface. The quantity of water shall be changed as necessary, with variations in the nature or moisture content of the aggregates, to maintain uniform production of a desired consistency. The consistency of the concrete shall be determined in accordance with DIN 1048.

### Concrete Mix Design

The various classes of concrete shall be designed by the Contractor with particular attention to durability, strength, workability and surface finish and to satisfy the Engineer on these qualities. The content of all concrete shall be rigidly controlled and kept to the minimum required to obtain a workable concrete suitable for the nature of the work to be executed. The addition of proprietary admixtures intended to change the flow characteristics, cohesion or rate of setting needs approval by ~~of~~ the Engineer. No admixture shall contain more than trace levels of chloride ion.

No concrete shall be placed in the Works until the relevant mix has been approved by the Engineer. Approval will not be given to any concrete mix until it has been successfully subjected to Preliminary Mix Tests.

The Contractor shall carry out Preliminary Mix Tests as specified hereinafter in order to determine for each class of concrete the minimum practicable water/cement ratio and the required mix proportions of the fine and coarse aggregate the necessary allowance being made for the moisture content of the aggregate. After the value of the water/cement ratio and the mix proportions have been approved by the Engineer, Trial Mixes shall be carried out by the Contractor as specified hereinafter. The water/cement ratio and mix proportions which have been approved as a result of the Preliminary Mix Tests shall be used throughout the course of the Works. The Contractor shall ensure that cube crushing strengths satisfies the compliance requirements specified hereinafter.

In concrete made with sulphate resisting cement the maximum total content of chlorides (as chloride ions) shall not exceed 0.2% by weight of cement and the total acid soluble sulphates (as sulphate ions) shall not exceed 4.0% by weight of cement.

Further tests shall be carried out if any feature of materials or mixes is changed during the course of the work.

### Preliminary Mix Tests

The proportions of cement aggregate and water determined by the Contractor in his mix designs shall be used in preliminary mixes of concrete made in the presence of the Engineer and tested for strength, workability and surface finish under laboratory conditions observing the appropriate requirements of these Technical Requirements and to satisfy the Engineer on these qualities. Preliminary mixes shall be repeated with adjusted proportions as necessary until concrete mixes meeting the relevant requirements.

### Trial Mixes of Concrete

Trial mixes of concrete shall be prepared and tested at the site by the Contractor in this presence of the Engineer after Preliminary Mix Tests have been completed and when the Engineer has approved the Contractor’s mix design for each class of concrete. Trial mixes of concrete shall be mixed for the same time and handled by means of the same type of plant as the Contractor proposes to use in the Works. Sampling and testing of trial mixes shall be in accordance with these Technical Requirements.

Three separate batches of concrete shall be made for each class of concrete. Each batch shall comprise not less than 0.5 m3 of concrete, unless otherwise approved by the Engineer. Three cubes shall be made from each batch of concrete. The average strength of the nine cubes made for each class of concrete and tested after 28 days shall exceed the specified characteristic strength by at least margins mentioned in these Technical Requirements.

Unless otherwise approved by the Engineer the Contractor shall carry out practical tests on the site with Trial moulds. Trial moulds shall be made for reinforced and plain concrete with dimensions typical of the Works. The formwork face to the trial moulds for each class of concrete shall be designed to display all the relevant surface finishes intended for use in the Works and specified in ~~the~~ these Technical Requirements. In making, transporting, placing, compacting and curing the Trial Mix concrete in the trial moulds the Contractor shall observe all the relevant requirements of these Technical Requirements. When curing has been completed the trial moulds shall be stripped and the concrete thus revealed shall be submitted for the approval of the Engineer.

When a proposed mix has been approved, no variation shall be made in the mix proportions, or in the type, size, grading zone or source of any of the constituents without the consent of the Engineer, who may require further trial mixes to be made.

Where the Contractor intends to purchase factory-made pre-cast concrete units, trial mixes may be dispensed with, provided that evidence is given to satisfy the Engineer that the factory regularly produces concrete which complies with these Technical Requirements. The evidence shall include details of mix proportions, water/ cement ratio, workability and strength obtained at 28 days.

### Concrete Testing

The Contractor shall make all necessary arrangements for the sampling and testing of fresh and hardened concrete in the extent and numbers of samples required by EN 1992.

Slump tests shall be carried out at such times and places as the Engineer may direct and shall be used as a guide to the consistency of each class of mix. The degree of slump will be decided by the Engineer following Trial Mix Tests and the figure given shall be adhered to thereafter.

Crushing tests shall be carried out on concrete cubes formed in 150 mm moulds.

Prior to the commencement of construction of the Works concrete test cubes shall be taken and tested in accordance with the requirements of these Technical Requirements.

During the course of construction of the Works concrete test cubes in sets of four shall be made at such times and places as the Engineer may direct and in any case at not less than the average rate of one set of cubes per 20 m3 of concrete. Two cubes from each set shall be tested at an early age (normally 7 days) as approved by the Engineer and the results so obtained shall constitute part of the Contractor’s quality control procedure. The remaining two cubes from each set shall be tested after 28 days and the average of these two results shall be taken as the Test Result for use in judging compliance with the characteristic strength requirements of the Technical Requirements. Particular care must be taken to ensure that the test cubes are stored under uniform conditions throughout the year, including a complete covering of damp thick sheet or similar approved material constantly sprayed with water whilst in the moulds and during any transit between Site and laboratory, and also including subsequent storage in water kept strictly within the specified temperature range.

The cost of sampling, making and curing Works test cubes together with the provision of moulds, all other necessary equipment and apparatus and the packing and transport to the laboratory, shall be included in the prices.

All cubes shall be marked at the time of casting, with the date, class of concrete and other necessary markings to identify the part of the Works, from which they are taken.

### Compliance Requirements for Concrete

During the course of the Works and after satisfactory completion of Preliminary and Trial Mix tests the compliance of concrete mixes with the requirements shall be determined as detailed below.

Compliance with the cement content requirements shall be satisfied if the conditions given in 1. or 2. Below are met:

1. Where compliance is determined by observation of batching or from autographic records the cement content shall not be less than 95% or more than 105% of the value approved by the Engineer for each concrete mix.
2. Where compliance is assessed from the results of analysis tests on fresh concrete the cement content shall not be less than 90% or more than 110% of the value approved by the Engineer for each concrete mix.

The Contractor shall provide facilities as required by the Engineer to enable the latter to check compliance with the cement requirements.

Compliance with the maximum values of water/cement ratio approved by the Engineer for each class of concrete mix shall be assessed by means of slump tests following the approval by the Engineer of slump values for each class of concrete mix.

The tolerance which shall subsequently apply to test results shall be 1/3 of the approved slump.

Compliance with the characteristic strength requirements shall be based on cube test result determined in accordance with the relevant requirements of ~~the~~ Sub-clause 6.6.8 Concrete Testing

Should cube test results fail to satisfy requirements the Contractor shall remove the concrete represented by the non-complying cubes or execute such other measures as the Engineer may direct.

The Engineer may require that additional testing by one or more of the methods detailed in DIN 1048 be carried out by the Contractor upon concrete represented by non-complying cubes. The results of any such additional tests shall not nullify the previous establishment of non-compliance with this Section.

If requirements (c) above is not satisfied the Contractor shall unless otherwise directed by the Engineer immediately cease production of the particular class of concrete mix represented by non-complying cube test results and shall repeat for that class all the stages specified in the Sub-clause 6.6.5 Concrete Mix Design.

All costs consequent upon non-compliance with the specified requirements for concrete shall be borne by the Contractor.

### Mix not Approved

Approval of a mix may be withheld or withdrawn under the following circumstances:

1. The grading of the aggregate changes such that the fraction of aggregate retained on any sieve differs from the corresponding fraction of aggregate in the approved mix by more than 2% of the total quantity of fine and coarse aggregates.
2. The source of supply of aggregate or cement is changed.

In the event that approval of a mix for any class of concrete is withdrawn for any reason the Contractor shall carry out such further trials and tests in order to achieve a satisfactory mix for that particular class of concrete.

### Additional Testing of Concrete

If the results for the compressive strength of the concrete used in the Works do not fulfil these Technical Requirements or if defects of workmanship during construction give rise to doubt as to the strength, durability and/or safety of the structure or of part thereof, supplementary testing may be required to be performed.

Concrete of water or sludge retaining structures shall be tested non-destructively with a rebound tester (“Schmidt hammer”). The Contractor shall supply and maintain such a device. [new]

Concrete of any other structure shall be tested destructively by tests of concrete cores.

Concrete cores shall, where ordered by the Engineer, be drilled or cut perpendicular to the face of the hardened concrete and tested in accordance with DIN 1048.

The cores shall be approximately 150 mm in diameter and, where possible, have a height/diameter ratio of two. Where it is not possible to take a core of this height/diameter ratio of two, the correction factor given in DIN 1048 shall be applied to give the equivalent strength of a cylinder having a height/diameter ratio of two.

If the compressive strength of the cores, adjusted for height/diameter ratio and age, fails to attain the specified characteristic strengthen 28 days, the suspected part of the concrete shall be cut out, removed and replaced with concrete to the satisfaction of the Engineer at no extra cost.

### Water Content

A check on the moisture content of the aggregate shall be made before concreting is commenced. For the propose of assessing the amount of free water to be added at the mixer, the Contractor shall provide himself with a chart, a copy of which shall be given to the Engineer for approval, relating moisture content in the aggregate to water to be added at the mixer for all Classes of concrete in use.

The amount of water introduced into the mix shall be strictly controlled and shall be the minimum amount consistent with complete compaction. The device for measuring water shall show accurately the quantity and be so designed that the water supply will be automatically cut off while water is being discharged into the mix.

### Weigh Batching and Mixing

Volume batching is under no circumstances allowed expect the conditions mentioned in this Section.

Concrete shall be mixed to the approval of the Engineer.

All plant and equipment used for batching and mixing concrete and concrete materials shall be and shall be provided with the means to permit quick and accurate checks on calibration. Sun shades shall be provided over stock piles of aggregates, cement and mixing water tanks.

Materials for all classes of concrete shall be proportioned by weight in an approved weigh batch and shall be thoroughly mixed so as to ensure a uniform distribution of the materials throughout the concrete.

The type of the mixer shall be in accordance with the maximum nominal size of the aggregate. The materials shall be mixed for a period and at a drum speed specified by the manufacturer of the mixer. Mechanical means shall be provided for recording the number of revolutions for each batch and automatically preventing the discharge of the mixer until the materials have been mixed for the specified minimum time.

The accuracy of such equipment shall be maintained within the tolerance specified by the manufacturer of the mixer~~.~~

Weigh batching machines shall provide facilities for the accurate control and measurement of the aggregates either singly or cumulatively and shall be capable of immediate adjustment by semi-skilled operators in order to permit variations to be made to the mix. All weigh dials shall be easily visible from the place at which filling and emptying of the hoppers is controlled.

Cement used in the production of concrete may be measured by making the size of each batch of concrete such as to require an integral number of complete bags or drums of cement. The maximum size of the batch shall not exceed the maximum rated capacity of the mixer as stated by the manufacturer and as stamped on the mixer.

Weight batching equipment shall be kept clean and maintained in good order. If any mixer is out of operation for more than 20 minutes is shall be thoroughly cleaned, together with all the handling plant, before any further mixing of concrete shall commence. Under no circumstances shall a batch of concrete be mixed with more than one type of cement~~.~~

The weights of the fine and coarse aggregates shall be adjusted as appropriate to allow either for free-water contained in the aggregates or for aggregate absorption. The quantity of water which has to be added to each concrete mix shall as appropriate be either reduced by the amounts of free-water contained in the fine and coarse aggregates or increased to allow for aggregate absorption. The values of either free water content or of absorption for the fine and coarse aggregates shall be determined by the Contractor by a method approved by the Engineer immediately before mixing begins and at such further intervals as the Engineer may require.

Every concrete mixing machine shall be fitted with a device to measure added water by weight or volume and shall be so constructed that the water inlet and outlet valves are interlocked so that neither one of them can be opened unless the other is fully closed. The device shall be provided with an overflow with a cross-sectional area at least 4 times that of the inlet pipe and with its discharge point clear of the mixing plant. The entire water system shall be maintained free of leaks at all times and the measuring device shall be fitted with a drain pipe which allows the full quantity of water being measured to be drained off for checking the measurement. The outlet arrangement of the measuring device shall be such that between 5% to 10% of the water enters the mixer before the other materials and a further 5% to 10% of the water enters the mixer after the other materials. The remainder of the water shall be added at a uniform rate with the other materials. The water measuring device shall be readily adjustable so that the quantity of the water added to the mixer can, if necessary, be varied for each batch.

Any admixtures which may be used shall be measured separately in calibrated dispensers. The accuracy of calibration of any weighing plant, water measuring device and admixture dispenser shall be checked before carrying out trial mixes, before the first mixing of concrete for inclusion in the Works, after each service or adjustment to the mixing plant, and in any case at least once per month.

Before the commencement of concreting operations for any particular section of the Works, the Contractor shall satisfy the Engineer that sufficient plant is in working order, including adequate stand-by equipment, in order to ensure the proper mixing of the concrete required during the period of placing.

The first batch of concrete materials placed in the mixer shall contain sufficient amount of excess cement, sand and water to coat the inside of the drum without reducing the required mortar content of the mix. Upon cessation of mixing for a considerable period, the mixer shall be thoroughly cleaned. Mixing for each batch shall continue until there is uniform distribution of the materials and uniformity of colour and consistency of the concrete. Admixtures for which approval in writing has been given by the Engineer shall be introduced into the concrete by means of automatic dosing equipment. Such equipment shall feed a fixed quantity of admixture into the mixing water before the latter is discharged into the mixer and shall be subject to the approval of the Engineer.

The Contractor shall take particular care to ensure that no residual materials remain in the mixer after depositing each batch of concrete and he shall wash and clean out the mixer drum immediately following the completion of each concreting operation or when changing to a mix using a different type of cement.

The Engineer may, at his discretion, forbid the mixing of any concrete if he considers the ambient temperature too high. The Contractor may also be required by the Engineer to carry out frequent cleaning of equipment to remove deposits of hardened or dried concrete which accretes rapidly at high air temperatures.

### Ready-Mix Concrete

Ready-mix concrete shall comply in any aspect to the Specifications. [new]

Concrete shall be handled from the place of mixing to the place of final deposit as rapidly as practicable by means, which will prevent the segregation or loss of any ingredient.

For the concrete transported by transit mixer or agitators, the time elapsing from the time water is added to the mix until the concrete is deposited in place shall not be greater than the time taken for 300 revolutions of the transit mixer or agitator or 20 minutes, whichever is the least.

Driver of delivery trucks shall be provided with trip tickets, which shall be signed by a responsible representative of the Contractor, for submission to the Engineer. The ticket shall contain name and address of the concrete mixing plant, serial number of the ticket and date, truck number, class and/or strength of concrete, cement content of the mix, loading time, slump and any other type of relevant information. The Engineer may send his representative to the concrete mixing plant to check the batching and mixing verify loading time and take a copy of the trip ticket.

Wherever practicable the mixer shall transport the concrete to the place of final deposit and the concrete shall be emptied from the mixer directly into the concrete pump sump to avoid re-handling or flowing.

### Sand-Cement Mortar

Sand-cement mortar shall be composed of sulphate resisting Portland cement, hydrated lime and sand. The proportions of these materials determined by the Contractor in his mix design shall be used in preliminary mixes of mortar made and tested for strength and workability under laboratory conditions.

Trial mixes of mortar shall be prepared and tested by the Contractor in the presence of the Engineer. Trial mixes of mortar shall be mixed for the same time and handled by means of the same plant as the Contractor proposes to use in the Works.

Three separate batches of mortar shall be made. Each batch shall comprise not less than 0.5 m3 of mortar. Six 150 mm cubes shall be made from each trial batch of mortar. Three shall be tested after 7 days and three shall be tested after 28 days. The average strength of the six cubes of mortar tested after 28 days shall be 10 MPa. Cubes which lie outside the range 8 MPato 12 MPa shall be deemed to have failed. If any of the cubes from the trial batches of mortar fail the mix shall be re-designed.

Where re-design of any mortar mix becomes necessary the making and testing of the trial mixes shall be repeated until the trial mix satisfies the above requirements.

When the mortar is being poured six test cubes shall be made from every 50 m3 batched. Three shall be tested after 7 days and three shall be tested after 28 days. The Contractor shall keep detailed records of the position of each pour and the relation to test cubes taken. Should the 28-day test results indicate that the specified strengths are not being achieved the Contractor shall check and modify his mix details to the Engineer’s approval before further pours of mortar take place.

## Placing and Concrete Compaction

Mixing, placing and curing of concrete shall be made in accordance with EN 206-1.

### Preparatory Work

The Engineer’s approval in writing shall always be obtained before any concrete is placed in the Works. All constructional plant and materials required, or which may be required during the concreting work and for curing shall be on site and the Contractor shall be fully prepared for the work. The Engineer’s approval to place concrete will only be given after such preparations and other relevant requirements of these Technical Requirements. Have been carried out and complied with.

If necessary and/or directed by the Engineer, the Contractor shall cool any shuttering that has become overheated or exceptionally dry through prolonged exposure to the sun. The Contractor shall ensure that all shuttering retains a sufficient amount of humidity and has not become shrunk or warped. All soaking or spraying of shuttering shall be done with potable water.

When concreting in hot weather the requirements of these Technical Requirements shall be complied with. The Engineer may completely forbid the placing of concrete in any shuttering, which he believes has become too and/or dry and the condition of which could harm the quality and strength of concrete. No extra payment for cooling or soaking of shuttering shall be made.

Pursuant to Sub-clause 1.7.1 (Cleaning and Re-using of Shutering) all shuttering, area of deposition, reinforcement and exposed surfaces of adjoining concrete surface shall be thoroughly cleaned and free from dust, debris, oil any other substance that may be harmful to fresh concrete.

### Depositing in Work

The methods of conveying and depositing concrete shall be such as to prevent segregation of the materials and shall be approved by the Engineer before concreting begins. The placing and compaction of concrete shall be carried out under the direct supervision of a competent member of the Contractor’s staff.

Should the Contractor propose to use concrete pumps for the transporting and placing of concrete. He shall submit full details of the equipment and operating techniques he proposes to use for the approval of the Engineer. [G14.4.12, paragraph 3]

Where concrete is conveyed by chutes or pumping the plant used shall be designed to ensure continuous and unimpeded flow in the chute or pipe. The delivery end of the chute or pump shall be thoroughly flushed with water before and after each working period and shall be kept clean. Water used for this purpose shall be discharged away from any permanent works. [G14.4.12, paragraph 4]

Before the commencement of concreting operations for any particular section of the Works, the Contractor shall satisfy the Engineer that sufficient pumps are in working order, including adequate stand-by equipment, in order to ensure the proper mixing of the concrete required during the period of placing.

Concrete shall be placed directly in the Works as soon as possible without the need for re-handling and not more than 45 minutes after mixing and in any case, before the initial setting has taken place. If any delay has occurred after mixing and the concrete has begun to set, it shall not be used in the Works and shall be removed from the site. Unless otherwise agreed by the Engineer on the basis of satisfactory site trials concrete shall not be dropped into place from a height exceeding 2 m.

Concreting of any section or unit shall be carried out in one continuous operation up to the construction joints. ~~and no~~ Interruption of the concreting will not be allowed concreting water retaining structures. For all other structures no interruption of the concreting will be allowed without the approval of the Engineer. Where deposition of concrete has to be interrupted, precautions shall be taken to ensure satisfactory adhesion of later batches of concrete to that previously placed.

Where delays of more than one hour has occurred between concreting operations in one section or unit of work, concreting shall only be resumed when, in the opinion of the Engineer, the previously placed concrete has had ample time to harden and the resulting joint shall be treated as a construction joint within the meaning and description of Sub-clause 1.6.8 hereafter. At all times when concrete is being placed, a competent steel fixer shall be in continuous attendance to adjust and correct the position of any reinforcement, which may become displaced.

Transportation of concrete directly over fixed reinforcement steel during concreting shall not be allowed unless proper provisions are made to avoid displacing or damage to the reinforcement.

### Depositing in Layers

Concrete shall be deposited in approved quantities and horizontal layers of such depth as to permit thorough incorporation with the layers below by vibration, spading, ramming and working. If, for unforeseen reasons, it is necessary to stop concreting before completion of a section, then construction joints as specified shall be formed and further concreting shall be suspended for at least 24 hours.

### Concrete Placed in Water

Concrete shall not be placed under water without the written approval of the Engineer. The Contractor shall submit his detailed proposals of the plant and method for underwater concreting.

The quantity of cement in any concrete placed in water shall, if necessary, be increased so that the water/cement ratio is not more than 0.02 from the values given in Sub-clause 6.6.5 Concrete Mix Design. The method of placing concrete under water shall be such as to keep as much as possible of the concrete being placed out of direct contact with the water so as to avoid any rapid movement or agitation of exposed surfaces. The work shall where possible be carried out in one operation. Where this is impracticable, laitance, washed out aggregate or foreign matter which may have accumulated on the previously placed concrete shall be completely removed prior to additional concrete being placed. This concrete shall then be placed directly on the cleaned surface. Funnel pipes shall be smooth bored, watertight and fitted with quick release joints and have an adequate cross-section for the size of aggregate to be used. Bottom opening skips shall be straight sided, perfectly smooth, and fitted with externally operated bottom opening double doors and overlapping canvas flaps. Toggle bags shall be used only for small pours and for depositing small discrete quantities of concrete. Bagged concrete shall not be used for permanent work.

During and after concreting underwater, pumping or dewatering operations in the immediate vicinity shall be suspended until the Engineer permits them to be continued.

### Concreting in Hot Weather

The Contractor's methods shall comply with the recommendations in that document as modified and supplemented below.

The Contractor's attention is drawn to ACI 305 recommendations on placing of concrete in hot weather.

The Contractor shall take great care during hot weather (air temperature exceeds 25°C) to prevent early setting of the concrete causing augmented cracking or crazing. The Contractor shall arrange for concrete to be placed in the early morning or late evening as directed by the Engineer.

The Contractor shall pay particular attention to the requirements specified herein for curing.

Formwork shall be shaded from direct exposure to the sun both prior to placing of the concrete and during its settings. The Contractor shall take appropriate measures to ensure that reinforcement in the section to be concreted is maintained at the lowest temperature practicable (spraying with water).

Concrete at placing shall have a temperature of not more than 32°C. If necessary the Contractor shall cool the aggregates and mixing water by methods approved by the Engineer.

Where necessary the Contractor shall design, install and operate a cooling system by which cooling water is pumped through a piping system in order to decrease the heat of hydration during concreting. The proposal for such a cooling system shall be submitted to the Engineer for his approval well in advance of the concreting operations.

The temperatures of ambient air, concrete at various levels and intervals not exceeding 5 m and cooling water where applicable shall be measured by means of thermocouples and recorded with a appropriate and approved recorder.~~.~~

During very hot weather conditions, the Contractor may be required to cool formwork containing concrete by spraying with water. All materials, spray equipment and an ample supply of water for curing shall be ready on site before any concreting starts.

### Concreting in Cold Weather

Cold weather is defined as the situation existing at the Works, where either or both of the following conditions existing:

1. The air temperature at the time considered is below 2°C;
2. The mean daily air temperature over three or more successive days has dropped below 5°C.

Under no circumstances may concrete be placed in contact with frozen ground or formwork, or in contact with ice, snow or frost on the ground or on formwork or reinforcement. Concrete shall not be made with frozen materials.

Concreting may proceed in cold weather provided special precautions are taken to ensure that the surface temperature of the concrete at the time of placing is not less than 5°C for a succeeding period of at least:

* 4 days when the cement used in the concrete is ordinary Portland cement;
* 2 days when the cement used in the concrete is rapid hardening Portland cement.

Such precautions may include the following:

1. Warming the aggregates and heating the water, provided that the temperature of either does not exceed 35°C. Water and aggregates shall be mixed for a period sufficiently long for them to acquire a uniform temperature before cement is added.
2. Completely surrounding the freshly placed concrete with a cover and heating the enclosed air, which shall be kept moist. Draughts of hot or dry air shall not be directed at surfaces.
3. Insulating the formwork and finished concrete surfaces.
4. Providing screens to protect the concrete from air currents.

The Contractor shall provide the Engineer with details of the precautions he proposes to take to protect the concrete from the effects of low temperatures and with details of the methods he proposes to use assess the correct timing at which such protection may be removed. No concreting shall be done in cold weather prior to the approval the Engineer for the proposed measures.

### Concreting in Unfavourable Weather

Concreting will not be permitted during heavy rain or snowfall. Concrete in Large Pours

A large pour is defined as a pour where the least dimension is greater than 1.5 m.

Subject to the requirements for construction and movement joint locations and the requirements for the test blocks detailed in the following Section, the Contractor will not be limited as to the size of a large pour, provided that adequate measures are taken to control temperature differentials. Such measures will be evaluated with reference to the following;

**a. Temperatures:**

1. The temperature of the concrete at the time of placing shall not exceed 15°C and peak hydration temperature shall not exceed 60°C, except under hot conditions, when the requirement of Sub-clause 1.6.7 (Concreting in Hot Water) shall apply.
2. The difference in temperature between thermometer readings in the concrete near any concrete face and the interior of the concrete at a distance of 1 m from that face shall not exceed 20°C at any stage after placing.

**b. Monitoring of temperature changes:**

Sets of thermometers for recording concrete temperatures shall be placed at positions in the concrete near to each exposed face at spacing not exceeding 5 m. Further sets shall be placed at corresponding positions within the concrete at a distance for 1 m from each face. The concrete temperatures shall be recorded at intervals not exceeding 6 hours, or such other intervals as may be required by the Engineer, for a period of at least 7 days.

Where the minimum dimension of a pour lies between 1.5 m and 2.0 m the internal temperatures shall be recorded by thermometers placed at mean depth of the least thickness.

**c. Insulation and protection of concrete surfaces:**

1. Formwork shall be plywood 19 mm thick, or such other combination of materials having an equivalent insulation value. The formwork shall remain in position for a sufficient time to ensure that the temperature control requirement in a.1 above can be maintained.
2. Uniformed surfaces shall be protected, as soon as practicable after the initial set has taken place, by either of the following means:

* by pounding the surface with at least 100 mm depth of water;
* by covering the surface with hessian sheets and a layer of polythene sheet upon which shall be placed a layer of sand of at least 50 mm thickness.

When the latter method of protection is adopted, the Contractor shall take appropriate steps to ensure no loss of sand is suffered through the action of wind; the thickness of the sand layers shall be maintained at the specified minimum of 50 mm at all times.

Whichever method of protection is adopted, the protection itself shall be kept shaded from direct sunlight.

The Contractor shall provide the Engineer with details of the precautions he proposes to take to protect the concrete from the effects of temperature build-up and with details of the methods he proposes to use to assess the correct timing at which the protection may be removed. No concreting in large pours shall be put in hand until the proposed measures have been approved by the Engineer.

### Test Blocks

Before commencing any large pour (as defined in the preceding Section) for a particular mix of concrete, the Contractor shall construct three test blocks 2.0 m cube in size. The temperature of the concrete at the time of casting the blocks shall not exceed 15°C except under hot conditions, when the requirements of these Technical Requirements will apply. The materials used in making concrete for the test blocks, together with the reinforcement, formwork and materials used for protecting the top surfaces, shall be of the same type and from the same source as those as those intended for the large pour.

Two of the blocks shall be reinforced on two opposing sides and on the top face by 32 mm diameter high yield reinforcing bars 250 mm spacing in each direction. The cover to the outer bars shall be 60 mm.

The Contractor shall ascertain the thermal characteristic of the cement and aggregates to be used, from which he shall calculate the likely maximum rise in temperature of the concrete. The data used shall be clearly indicated in the calculations which the Contractor shall give to the Engineerbefore casting the blocks.

Thermometers shall be installed in the concrete near to the surface at the centre of each face, with one placed centrally in the block. Temperatures shall be recorded at 6 hourly intervals for a period of at least 7 days for each of the blocks.

Six 150 mm test cubes shall be taken during placement of the concrete for each block, two for testing at 7 days and four for testing at 28 days.

The test blocks shall be considered satisfactory if all the following conditions are met for each of the blocks:

1. The average strength of the four 28 day test cubes exceeds the specified 28 day characteristic strength by at least 7.5 MPa;
2. The rise in temperature during hydration does not exceed 45°C and the difference in temperature between any face and centre of the block does not at any stage exceed 20°C;
3. The nature of any cracks appearing is such that, in the opinion of the Engineer, the cracks would not constitute a potential source of harm if they were to occur in the Permanent Works.

If condition 1. above is not fulfilled the Contractor shall redesign the concrete mix, construct further test blocks, and repeat the testing as specified.

If condition 2. is not fulfilled or if under 3. the Engineer is of the opinion that the cracks as noted are potentially harmful, the Contractor may proceed with the casting of a large pour only if he incorporates one or more of the following procedures in the concreting operation:

* cool the mixing water/aggregates as set out in Sub-clause 6.7.5 Concreting in Hot Weather;
* replace the 19 mm plywood from work to formed faces with material having better insulating properties;
* increase the surface protection to informed faces.

If the Engineer so requires, the Contractor shall construct further test blocks to demonstrate the efficacy of the measures which are being incorporated in the casting of the large pour.

### Compaction of Concrete

The Contractor shall regard the compacting of the concrete as work fundamental importance the object of which shall be to produce a watertight concrete of maximum density and strength.

Concrete shall be thoroughly compacted during the operation of placing and shall be thoroughly worked around the reinforcement and embedded fixtures and into corners of the formwork and moulds.

Mechanical vibrators shall be of the immersion type with a frequency of not less than 6,000 vibrations per minute and as approved by the Engineer. A sufficient number of vibrators shall be used to handle the maximum rate of concrete production with a 50% allowance for stand-by units during any period of concreting. All operators handling vibrators shall be trained in their operation.

Vibrators shall be inserted into the uncompacted concrete vertically and at regular intervals. Where the uncompacted concrete is in a layer above freshly compacted concrete the vibrator shall be allowed to penetrate vertically for about 10 cm into the previous layer. Vibrators shall be withdrawn slowly from the mass of concrete so as to leave no voids. Internal type vibrators shall not be placed in the concrete in a random or haphazard manner nor shall concrete be moved from one part of the work to another by means of the vibrators.

Vibration shall not be applied directly or through the reinforcement to sections or layers of concrete which have hardened to the degree that the concrete flow in the formwork over distances so great as to cause segregation. Vibration of concrete shall generally comply with the requirements as specified in DIN 4235.

Every care shall be taken to see that reinforcement and fittings attached to the shuttering are not disturbed, and that no damage is caused to concrete that has already set or to the internal face of the shuttering by using immersion type vibrators. In areas of congested reinforcement, it may be necessary to use small diameter pokers and the Contractor shall supply suitable sizes of pokers for each part of the work. Vibration of concrete by hammering the shuttering with hand tools is not permitted.

When placing concrete against horizontal or inclined elements of water stops they shall be lifted and the concrete placed and compacted to a level slightly higher than the underside of the water stop before releasing the water stop to ensure complete compaction of the concrete around the water stop.

The duration of vibration shall be limited to that required to produce satisfactory compaction without causing segregation. Vibration shall not be continued after water or excess grout has appeared on the surface.

Concrete shall not be disturbed after compaction and placing in its final position. Concrete that has partially set before final placing shall not be used and shall be removed from the site.

### Placing Concrete on Previously Executed Work

Where concrete is to be poured against or on top of previously executed work, the surface of the old concrete shall be thoroughly wire brushed, hacked and cleaned with water and air under pressure to expose the surface of the aggregate and to remove all laitance.

Special care shall be taken to ensure that the new concrete is thoroughly compacted and rammed against the old. In certain cases, depending on the class of concrete in use, the elapsed time between successive concreting operations and the weather conditions at the time of recommencing concreting, the Engineer may require the old concrete to be treated differently, including the use of "wash-off" and "wash-off" and "dry-bond" techniques, wire brushing, etc.

### Protection and Curing of Concrete

Concrete shall be protected from damage by climatic conditions (direct sunlight, rain, snow or frost), running water or mechanical damage during curing. All methods to be used for curing and protection of freshly placed concrete shall be subject to the prior approval of the Engineer.

The maximum and minimum ambient temperatures and humidity shall be measured and recorded each day by the Contractor. The records shall be made available for the Engineer's inspection.

All exposed surfaces shall as finishing proceeds be covered with a wet hessian sheet followed by a reflective polythene sheet. These shall be securely fastened around the edges and supported in order not to damage the finished concrete surface. As soon as practicable the hessian and polythene shall be lowered into close contact with the concrete and securely weighted or fastened down to prevent wind blowing underneath. The hessian sheet shall be maintained in a moist condition at all times and shall be inspected at intervals not exceeding 6 hours. Concrete shall be kept moist on exposed surfaces for a period of not less than 10 days or as approved by the Engineer.

Alternative methods of protecting and curing concrete may be approved by the Engineer. In any case liquid curing membranes shall not be used on exposed surfaces or where laitance is to be removed and aggregate exposed to provide satisfactory bond for placing further concrete or mortar screeds. Liquid curing membranes shall not be used where mortar, resin mortar, or joint sealant is to be applied.

Sufficient methods to afford full protection to a concrete pour shall be available at the place of work prior to the commencement of concreting.

### Record of Concreting

The Contractor shall keep complete, accurate and up to date records of the works on site, showing for each day the sections of the works concreted:

* Date, time, weather conditions and air temperature;
* Results of all concrete tests including identification for which part of works the sampled material is representative;
* Number of batches produced, weight and kind of cement used, volume of concrete placed, number of batches wasted or rejected;
* Class of concrete, volume of concrete placed and number of batches used for each location.

The laboratory where concrete test have to be carried out shall be approved by the Engineer and these Technical Requirements and be accessible for the said parties at any time. The laboratory should preferably be placed at the site.

### Faulty Work

Any portion of the work which is honeycombed, rust stained or otherwise inferior (like wrong dimensions) shall on the written instruction of the Engineer, be immediately cut out and reconstructed in an approved manner without extra charge. Plastering of defective work will not be permitted.

Any leaks or cracks shall be sealed from the inside of the tank by injection with a synthetic resin or other appropriate methods approved by the Engineer.

### Blinding Concrete (Sub-base)

A blinding layer (slap on grade) of minimum 7.5 cm concrete C12/15 shall be placed under foundations where shown on the drawings or ordered by the Engineer. The blinding layer shall be allowed to harden before the structural concrete for the foundation is placed.

### Loading of Concrete Structures

No external load of any kind shall be applied to any part of a concrete structure until the concrete has matured for at least 7 days and then only with the approval of the Engineer and after confirmation that 7 days cube strengths as agreed by the Engineer have been met.

## Joints

In order to incorporate the effects from thermal action, shrinkage and creep, the Contractor shall make construction joints or contraction joints in accordance with this Specification. The Contractor shall make his design calculations in accordance with the intended location of joints.

### Construction Joints

A construction joint is defined as a joint in the concrete introduced for convenience in construction at which special measures are taken to achieve subsequent continuity without provision for further relative movement.

The Contractor shall submit to the Engineer for his approval not less than 3 weeks before the commencement of concreting, drawings showing his proposals for placing concrete on which the position of all construction joints and lifts shall be shown. No concreting shall be started until the Engineer has approved the method of placing, the positions and form of the construction joints and the height of lifts. The construction joints shall be so located as not to impair the strength of the structure. Rebates, keys or notches shall be formed and water stops respectively joint plates inserted as specified or as the Engineer may require.

The position of construction joints and the size of formwork panels shall be so co‑ordinated that where possible the line of any construction joints coincides with the line of a formwork joint and that in any case all construction joint lines and formwork joint lines appear as a regular and uniform series. For all exposed horizontal joints and purposely inclined joints, a uniform joint shall be formed with a batten of approved dimensions to give a straight and neat line.

Shuttering for construction joints shall incorporate continuous shear keys of substantial proportions to produce watertight joints. Stop-ends shall be freely fixed, made grout-tight and be closely fitted to the reinforcement or other fixtures.

Concrete placed to form the face of a construction joint shall have all laitance removed and the aggregate exposed prior to the placing of fresh concrete. The laitance shall wherever practicable be removed by spraying the concrete surface with water under pressure and brushing whilst the concrete is still green. Where the laitance cannot be removed whilst the concrete is still green, the whole of the concrete surface forming part of the joint shall be hacked to expose the aggregate. Where aggregate is damaged during hacking it shall be removed from the concrete face by further hacking. All loose matter shall be removed and the exposed surface thoroughly cleaned by wire brushing, air blasting or washing, and the surface to which fresh concrete is applied shall be clean and damp.

Where wall kickers are used, they shall be at least 15 cm high and shall be cast monolithically with the wall base.

Unless otherwise specified, the minimum time interval between lifts in slabs shall be 72 hours. At least 72 hours shall elapse between pouring adjacent bays of slabs less than 1 m thick and at least 10 days for thicker slabs.

### Contraction joints

Complete contraction joints have no restraint to movement, but are intended to accommodate only contraction of the concrete. Partial contraction joints provide some restraint, but are intended to accommodate some contraction of the concrete. Both types of contraction joints are allowed in the works.

### Expansions Joints

Expansion joints are defined as all joints intended to accommodate relative movement between adjoining parts of a structure, special provision being made where necessary for maintaining the water tightness of the joint. The Contractor shall comply with the instructions of manufacturers of proprietary jointing materials and shall, if required by the Engineer, demonstrate that the jointing materials can be applied satisfactorily.

Expansion and contraction joints are discontinuities in concrete designed to allow for thermal or other movements in the concrete.

Expansion joints are formed with a gap between the concrete faces to permit subsequent expansion of the concrete. Contraction joints are formed to permit initial contraction of the concrete and may include provision for subsequent filling.

The following general requirements shall apply to both expansion and contraction joints:

* 1. **Filler Boards**

Filler boards in expansion joints shall be a performed material securely fixed at right angles to the surface of the concrete within a tolerance of one degree. The boards shall extend without any gaps from the underside of the sealing groove to the base and between side forms or existing slabs. Dowel bars where specified shall be a close fit where they pass through boards. Joints in boards shall be taped to prevent discontinuities.

* 1. **Dowel Bars**

Dowel bars shall be round mild steel complying with EN 10080 and shall be sawn or flame cut to length. Flame cut bars shall be dressed by grinding to remove any snags or lips. Dowel bars shall be straight without any irregularities likely to interfere with longitudinal movement in the concrete.

Dowel bars in expansion joints shall be fitted at one end with sleeves which are a sliding fit on the bar and which contain compressible filling in the end remote from the bar, all to the dimensions and details shown on the Drawings.

* 1. **Sealing Grooves and Sealant**

Caulking grooves shall be provided where necessary and as specified. At all joints where a caulking groove is formed, the groove shall be wire brushed and loose material removed and blown out by compressed air immediately prior to caulking. After the groove has dried, it shall be primed and caulked with approved jointing compound applied in accordance with the manufacturer's instructions. At all caulked joints, the face of the caulking strip and 50 mm width of concrete on either side shall be painted with two coats of primer having the same base as the caulking compound.

Joints in the concrete shall be sealed with an approved sealant by an approved manufacturer which is suitable for the particular location and environment. Joints shall be sealed immediately after the expiry of the concrete curing period or as soon thereafter as weather conditions permit.

Before sealing is carried out, the sealing grooves shall comply with the following requirements:

Grooves shall extend across the bays from edge to edge in the case of transverse joints and shall be continuous in the case of longitudinal joints.

In expansion joints, the filler material shall be exposed for the full length of the joint.

All grooves shall be dry and free of loose aggregate, paint, corrosion, oil, bitumen spillage, waterproofing agents, concrete curing agents, or release agents.

Bond breaking tape or other suitable material acceptable to the Engineer shall be placed in the bottom of the groove to leave the specified depth for the seal.

Primer shall be applied evenly to the sides of the grooves ensuring complete coverage. The interval between priming and sealing shall be within the limits specified by the sealant manufacturer. In dusty conditions, the primed joints shall be protected from contamination.

The sealant shall be prepared and applied in accordance with the manufacturer's instructions. Care shall be taken to avoid trapping air or forming bubbles and the finished surface of the sealant shall be smooth and free from blemishes to the specified level.

Expansion and contraction joints shall be formed in the positions and in accordance with the details shown on the drawings or elsewhere in these Technical Requirements.

* 1. **Waterstops**

Waterstops shall be of the material and form shown on the drawings and shall comply with ISO 11600, ICS 91.100.50 and ICS 91.120.30. No waterstop material shall be brought onto Site until the Contractor has submitted full details of the materials he proposes to use, including samples, and these have been approved by the Engineer. All samples shall be of adequate length for testing.

Waterstops shall be made of materials which are resistant to chlorides, sulphates, or other deleterious substance which may be present in the environment of the Works.

Rubber waterstops may be of natural or synthetic rubber and shall have an elongation at breaking stress of at least 500% at 23°C and shall be capable of accommodating a transverse movement of at least 50 mm.

Polyvinyl chloride (PVC) waterstops shall be extruded from an unfilled plasticised PVC polymer or copolymer which does not contain any reclaimed or scrap PVC. PVC waterstops shall have an elongation at breaking stress of at least 240% at 23°C and shall be capable of accommodating a transverse movement of at least 10 mm.

Low modulus waterstops shall be of rubber or PVC as described above but shall have an elongation of at least 200% at 23°C under a tensile stress of 6 MPa and shall be capable of accommodating a transverse movement of at least 50 mm.

Waterstops shall be supplied in lengths as long as possible consistent with ease of handling and construction requirements.

In rubber or plastic materials, joints other than butt joints shall be supplied ready made by the manufacturer. Butt joints shall be made on Site in accordance with the manufacturer's instructions and with equipment supplied for the purpose by the manufacturer.

Waterstops material shall be stored carefully on Site to avoid damage and contamination with oil, or other pollutants. Rubber and plastic waterstops shall be stored in cool well ventilated places away from direct sunlight.

Rubber and plastic waterstops which are embedded in one side of a joint more than one month before the scheduled date of placing concrete on the other side, shall be protected from the sun.

The Contractor shall submit to the Engineer for his approval, not less 3 weeks before the commencement of concreting, details of his proposals for the installation of waterstops. These shall show where joints are to be located and details of the intersections and changes of direction to a scale that shows the position of any joint or shape of any moulded section.

As far as possible, jointing on Site shall be confined to the making of butt joints in straight runs of waterstops. Where it is agreed with the Engineer that it is necessary to make on Site an intersection or change of direction or any joint, other than a butt joint in a straight run, a preliminary joint intersection or change of direction piece shall be made and submitted to such tests as the Engineer may require.

Flexible waterstops shall be fully supported in the formwork, free of nails and clear of reinforcement and other fixtures. Damaged waterstops shall be replaced and during concreting care shall be taken to place the concrete so that waterstops do not bend or distort.

Concrete shall be placed carefully round waterstops so as to avoid distortion or displacement and shall be fully compacted. Where waterstops lie in a horizontal or nearly horizontal plane, the Contractor shall ensure that no voids are left on the underside of the waterstops.

Formwork round waterstops shall be carefully removed to avoid damage. If waterstops suffer any damage which cannot be properly repaired in situ, the Engineer may require a section of concrete to be removed and the waterstops replaced.

When waterstops are placed for water tightness, the waterstops shall be made by an appropriate material resistant to chlorides, sulphates, chemicals and the like which is approved by the Engineer.

The width of the waterstops shall be according to the manufacturer's specifications.

All waterstops shall be made continuous and shall be welded at all connections. Overlapping shall not be allowed. All joints in waterstops shall be made by the manufacturer of the waterstop.

If a joint ends at another part of the structure, such as the connection between a wall and a bottom slab, the waterstop shall also be placed at least 300 mm inside the adjacent part of the structure.

Waterstops shall be placed in accordance with the manufacturer's specifications.

Waterstops shall be carefully placed and maintained in position during concreting and compaction operations. Concrete shall be carefully compacted around the waterstops so as to leave no cavities.

|  |  |  |
| --- | --- | --- |
| Waterstops shall fulfil the following requirements: Property at 25 °C | Rubber | PVC |
| Minimum tensile strength (N/mm2) | 20 | 15 |
| Minimum elongation at break (%) | 450 | 285 |
| Hardness (IRHD/ Shore A) | 60 - 75 | 70 - 75 |
| Softness (BS 2571) | 42 °C - 52 °C | |
| Specific gravity | 1.1 (+5%) | 1.3 + (5%) |

### Metal Components Cast in Concrete

All metal components to be fixed in the concrete such as pipe sections, frames and covers, hooks, ladders etc., shall be tightly placed in their right position within the shuttering prior to casting of concrete. All faces of metal parts that will be embedded in the concrete shall be thoroughly cleaned to remove all dirt, oil, paint, scale etc., in order to secure thorough adhesion between concrete and metal. In case a free passage of the pipe is required through the concrete, the pipe shall be wrapped with bitumen-saturated felt or a similar elastic sealing material.

## Testing of tanks

All tanks shall be tested for water tightness in accordance with EN 1992-3[[3]](#footnote-3). The testing procedure shall be according to the following procedure.

Excavation for tanks shall not be filled and tank wall faces shall not be coated or plastered outside and inside before the water tightness tests have been passed successfully.

* Filling of tanks with water shall take place with a constant flow rate. The chosen flow rate shall raise the level in the tank not more than 2 m height in 24 hours.
* A period of 1 week shall be allowed for saturation and stabilisation (admission of water into the concrete).
* Water levels shall be measured by approved means at 24 hours intervals for a test period of 5 days.
* During the test period the total permissible water level drop, after allowing for evaporation and rainfall, shall not exceed 1/500 of the average water depth of the full tank or 10 mm, whichever is greater.

The testing procedure shall be used also for small chambers (flow confluence or distribution chambers) and for manholes of gravity pipelines.

Notwithstanding the satisfactory completion of the above test, any leakage or soaking visible on the outside face of the tank walls shall be stopped, after allowing for self-sealing. Any sealing or making good of cracks in the concerned wall section shall, where practicable, be carried out from the inside face. Adjacent internal chambers within a structure shall be tested sequentially in case the treatment process allows for emptying of the respective chamber independently of the whole structure. In this case, the chambers adjacent to the chamber under test shall be empty during the test period.

# Shuttering and Concrete Finishes

## Standards

The Contractor shall carry out the works described in accordance with the appropriate standards or equivalent local or international standards. The main standards are, but shall not be limited by the following:

### Formwork

DIN 18218 Concrete pressure on vertical formwork elements

Shuttering shall include all temporary moulds for forming the concrete together with all temporary constructions required to support such moulds.

The Contractor shall bear the sole responsibility for the safety and stability of the forms, scaffolds etc., and in case of collapse, excessive deflections, buckling and/or any other changes in shape, the damage shall be repaired by the Contractor at his expenses.

### Drawings and Calculations

The Contractor shall submit drawings and calculations showings details of the shuttering he intends to use for the approval of the Engineer. The drawings shall show the materials proposed and indicate details of construction such as size of members, pacing and position of walling, struts, bolts and wedges.

If the Contractor wants to use climbing formwork or slipform systems he shall submit to the Engineer extensive and detailed description of set-up (striking, lifting, anchoring, erection, etc.) structure and working methods. Climbing formwork shall be firmly anchored to the existing concrete structures at all times.

Shuttering shall not be constructed until the drawings and calculations, (if applicable) have been approved by the Engineer. But such approval shall not relieve the Contractor of his responsibility for the adequacy and performance of the shuttering. Any changes or modifications to the shuttering required by any the Engineer shall be carried out at no extra cost.

Shuttering shall be of suitable design and adequate construction to carry the loads without excessive bulging, distortion or deflection. Shuttering shall be constructed so as to prevent loss of water or grout from the concrete and so as to permit easy removal without resorting hammering or levering against the surface. Special attention shall be paid to shuttering where poker or shutter vibrators are used for compacting the concrete.

The shuttering for circular tanks with a diameter larger than 5 m can be made with a polygonal form having a maximum length of each panel of 1 m.

### Materials for Shuttering

Shuttering shall be made from good quality timber, free from loose knots, shakes and warped surfaces. Timber for shuttering shall not be less than 19 mm in thickness, and the board faces in contact with concrete and the board edges shall be planed smooth and joints shall be tongued and grooved. Shutters used to have fair faced concrete shall be appropriate for this purpose.

Alternatively, with the approval of the Engineer, shuttering may be made from:

1. Metal with accurately aligned and close fitting joints;
2. Plywood or hardboard 5 mm in thickness supported by close boarded timber;
3. Plywood not less than 17.5 mm in thickness. The plywood or hardboard shall be resistant to deterioration by water, and shall be fixed and jointed in such a manner as to give a perfectly smooth and even finish to the concrete;
4. Plastic with accurately aligned and close fitting joints, sufficiently supported by close boarded timber.

For textured concrete forms refer to Sub-clause 7.1.11 Finish to Concrete Surfaces.

Faces in contact with concrete shall be free from adhering grout, projecting nails, splits or other defects. Joints shall be sufficiently tight to prevent the leakage of cement grout and to avoid the formation of fins or other blemishes. Faulty joints shall be caulked. 20 mm by 20 mm chamfers shall be formed on the external corners of concrete members, unless otherwise specified. Internal corners shall similarly be provided with 20 mm fillets.

Formworks for exposed surfaces shall be laid out in a regular and uniform pattern with the long dimension of panels vertical and all joints aligned, in accordance to EN206-1.

Concrete shall normally not be placed in lifts deeper than 3 m. For lifts higher than 3 m, openings for placing the concrete shall be provided in order to avoid segregation of the concrete.

### Fixing of Shuttering

Shuttering shall be fixed to perfect line and level and be truly plane with no crevices at joints, and shall be securely braced, supported and wedged so as to retain its position without displacement or deflection during the placing and compaction of the concrete.

All joints shall be either horizontal or vertical, unless the form of the finished concrete requires them to be otherwise.

### Back Shuttering

Back Shuttering shall be used to form concrete surfaces which are designed to be concealed by earth backfill or further construction, and shall comply with the specified requirements of shuttering except that the board faces are not required to be plane.

### Form Ties

Form ties shall be used to anchor the formwork. Form ties shall have sufficient strength to bear all forces from formwork anchoring. Steel quality shall be at least 835/1030 according to prEN 10138. Form ties shall be protected by spacer tube sheaths from PVC or fibre cement with sealing cones.

Metal ties or anchors within the form shall be so constructed as to permit their removal to a depth of at least 50 mm from the face without injury to the concrete. All fittings for metal ties shall be of such design that, upon their removal, the cavities which are left shall be of the smallest possible size. Spreader cones or ties shall not exceed 25 mm diameter. The cavities shall be filled with epoxy mortar and the surface left sound, smooth, even and uniform colour.

### Coating to Prevent Adhesion

All shuttering in contract with concrete shall be treated with an approved mould oil or solution before usage to prevent the adhesion of the concrete. Such oil or solution shall be carefully applied in such a manner that there is no contamination of the reinforcement or previously placed concrete by the oil or solution. Any materials which will adhere to or discolour the concrete shall not be used.

### Access Holes

Adequate access holes shall be left for the purpose of cleaning the shutters and for placing and compacting the concrete.

### Cleaning and Re-Using of Shuttering

Before any concrete is placed, the shutters shall be properly cleaned and washed out with water and air under pressure to remove sawdust, shavings and all other foreign matter. All water shall then be drained and mopped out from the shutter.

In no case shall concrete be placed in shuttering before the shuttering has been approved by the Engineer. If shutters or moulds are to be re-used, all surfaces shall be cleaned and shall be completely free from remnants of concrete or mortar. If in the opinion of the Engineer, shutters or moulds are not acceptable for reuse, they shall be either properly repaired or substituted with new shutters or moulds which shall comply with these Technical Requirements.

### Removal of Shutters

Shutters shall be removed only with the permission of the Engineer and under skilled supervision of a competent foreman and in such a manner as will not cause any damage to the concrete. Shutters shall not be removed before the concrete is sufficiently set and hardened.

The minimum periods which shall elapse between the placing of the concrete and the removal of the shutters for the various parts of the structures cast in-situ shall be in any case not less than the period stated in EN 1992-1.~~.~~ Should there be variations in site temperature and depending on the curing conditions, the Engineer may, at his discretion, extend ~~vary~~ the period

If not otherwise directed, the removal times for formwork shall be as follows:

Class of cement strength: 32.5 42.5 52.5

Side formwork for beams, walls, columns: 3 2 1 days

Formwork for floor slabs: 8 5 3 days

Formwork for beams, frames and long span slabs: 20 10 6 days

At all times the Contractor shall delay the removal of the shutter if in the opinion of the Engineer the concrete contained therein has not attained sufficient hardness.

In cases of average temperatures being below 4°C, the period of removal shall be extended by the number of days the temperature has been lower than 4°C. The periods given in days are days of 24 hours duration.

Alternatively, the removal of shutters shall be determined by the demanded compressive strength of the concrete with Sub-clause 1.6.6 (Water Cement Ration and Compressive Strength).

Climbing and sliding velocities of climbing and slide formwork shall be in accordance to the formwork manufacturer and setting characteristics of concrete have to be adjusted to the designed climbing and sliding velocities.

Any damage to the concrete, which may occur by removal of the shutters or by overloading, shall be made good at the Contractor's expense and to the satisfaction of the Engineer.

### Finish to Concrete Surfaces

The following requirements for the finish to concrete surfaces shall apply appropriate unless otherwise specified or shown on the Drawings.

1. Exposed surfaces (other than exposed upper surfaces), surfaces in contact with liquid including sewer inverts and outside vertical surfaces of in-situ caissons:

The surface texture required shall, unless otherwise specified, be that obtained from the use of a smooth impervious face of metal or the like.

1. Concealed surfaces:

The surface texture required shall be that obtained from the use of sawn close-jointed timber or the like.

1. Exposed upper surfaces:

Exposed upper surfaces of floor slabs and upper surfaces in contact with water shall be floated with steel trowel marks. Other exposed upper surfaces shall have a smooth uniform finish free from trowel marks. Other exposed upper surfaces shall have a smooth finish obtained with a wood float.

1. Concrete road and hardstanding surfaces:

Concrete road and hardstanding surfaces shall have the surface finish obtained by the conventional use of a hand tamper or vibrating beam.

1. Rendered or surfaced areas:

Areas to be subsequently rendered or to receive a surfacing shall be adequately scored to provide an effective key.

1. Exposed arises:

Exposed arises shall be formed with a chamfer 20 mm by 20 mm.

1. Textured concrete:

Surfaces to include a textured concrete finish shall be as detailed on the drawings. The Contractor shall construct a sample of 1 m2 for the Engineer's approval prior to constructing textured concrete in the permanent works.

1. All surfaces:

All surfaces shall be free from cracks, sand runs, honeycombing, porosity and grout/matrix loss.

For partly buried surfaces the exposed surface quality shall extend to 0.5 m below final ground level.

### Dimension and Surfaces of In-Situ Concrete

Workmanship in formwork and concreting shall be such that concrete shall normally require no making good, surfaces being perfectly compacted, smooth and with no irregularities. Concrete surfaces for the various finishes shall in any event never exceed the maximum permitted tolerances stated in the table below.

In the following table "line and level" and "dimension" shall mean the lines, levels and cross-section dimensions shown on the Drawings.

Surface irregularities shall be classified as “abrupt” or “gradual”. Abrupt irregularities include, but shall not be limited to, offsets and fins caused by displaced or misplaced formwork, loose knots or other defects in formwork materials, and shall be tested by direct measurement. Gradual irregularities shall be tested by means of a straight template for plane surfaces or its suitable equitable for curved surfaces, the template being 3.0 m long for unformed and 1.5 m long for formed surfaces.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Maximum Tolerances** (mm) for In-Situ Concrete | | | |
| **Finish** | Line and Level | Abrupt Irregularity | Gradual Irregularity | Dimension |
| Exposed or PVC/GRP/PE lined formed surfaces and surfaces in contact with liquid | ± 3 | 0 | ± 3 | ± 3 |
| Rendered formed surfaces | ± 6 | ± 3 | ± 6 | ± 6 |
| Other concealed surfaces | ± 12 | ± 6 | ± 6 | ± 12 |
| Exposed unformed surfaces | ± 6 | ± 3 | ± 3 | ± 6 |
| Concealed unformed surfaces | ± 12 | ± 6 | ± 6 | ± 12 |

The tolerances within which concrete work shall be constructed are as summarized below:

|  |  |
| --- | --- |
| tem of construction | Permissible deviation |
| Position in plan | ± 20 mm |
| Wall and slab thickness | ± 6 mm |
| Columns and beams | ± 6 mm. |
| Dimensions of foundations | + 50 mm / - 0 mm. |
| Variation from plumb: | (vertically - up to 5 m) ± 12 mm. |
| Levels to slabs and beams: | ± 10 mm. |
| Holes Placement: | ± 10 mm |
| Hole Size | ± 3 mm. |
| Cast-in items (reinforcement bars or wire strands) Placement: | ± 10 mm |
| Distance between interconnected items: | ± 2 mm. |

# Dry-Pack Mortar

## Dry-Pack Mortar for Concrete Structures not in Contact with Water or Sludge

Dry-pack mortar for filling holes and repairing surface blemishes shall be from one part by weight of cement and three parts fine aggregate passing a 1 mm sieve and an expanding agent approved by the Engineer. Additives to improve workability may be added to the approval of the Engineer. The colour of the mortar shall match that of the surrounding concrete. The mortar shall be mixed with only sufficient water to make the materials stick together when being moulded in the hands.

The dry-pack material shall be placed and packed in layers having a thickness not greater than 15 mm. The compaction shall be carried out by use of hardwood stick and hammer and shall extend over the full area of the layer, particular care being taken to compact the dry-pack against the sides of the hole. After compaction the surface of each layer shall be scratched before further loose material is added. Holes shall not be over filled and the surface shall be finished by laying a hardwood block against the dry-pack fill and striking the block several times. Steel finishing tools shall not be used and water shall not be added to facilitate finishing.

## Dry-Pack Mortar for Concrete Structures in Contact with Water or Sludge

Special dry-pack mortar for filling holes and repairing surface blemishes for concrete faces designed for contact with water or sludge shall be mixed of aggregates and cement as prescribed by the manufacturer. The colour of the mortar shall match that of the surrounding concrete. Placing shall be in accordance with the manufacturer’s instruction.

Special dry-pack mortar shall have the following characteristics and shall be approved by the Engineer before being applied:

* Applicable under water;
* Persistent to wastewater or sludge or their ingredients harming concrete;
* Good workability;
* Good adhesion to the concrete surface;
* Low invariance and deviation in dimensions;
* Modulus of elasticity and heat expansion coefficient similar to concrete, and
* Compression, tensile, and bending tensile strength equal or higher than of the concrete to be applied.
* Epoxy resin based mortars shall be used as bonding agent.

The Contractor shall provide material catalogues and method of application to the Engineer for his approval. No additional payments shall be done for these requirements and any necessary tests shall be carried out after repair.

# Remedial Treatment of Concrete Surfaces

Any remedial treatment to concrete surfaces shall be agreed with the Engineer following inspection immediately after the stripping of formwork and shall be carried out without delay.

Any concrete surface which is found to have been treated before inspection by the Engineer shall be rejected.

Any minor surface blemishes as air or rock pockets, gravel streaks, sand streaking, dusting, surface scaling etc. shall be repaired to the satisfaction of the Engineer immediately after completion of curing. Remedial measures may include, but shall not be limited to, the following:

1. Holes left for formwork ties supports shall be thoroughly cleaned out to remove all loose material and the sides shall be roughened, if necessary, to ensure a satisfactory bond. They shall then be filled with appropriate dry-pack special mortar to be approved by the Engineer;
2. Air or rock pockets, Fins, pinhole bubbles, surface discoloration and minor defects may be repaired rubbed down with sacking and cement immediately the formwork is removed. with special repair mortar;
3. Abrupt and gradual irregularities like gravel or sand streaks may be rubbed down with carborundum and water after the concrete has been fully cured. Loose and/or sticking out aggregates shall be broken out, the defective places shall be repaired with special repair mortar;
4. Small defects and minor honeycombing shall be chipped out perpendicular to the face of the concrete to a depth of at least 25 mm and filled with special repair dry-pack mortar as specified in these Technical Requirements.
5. Fissures shall be repaired according to these Technical Requirements.

All other defects will be regarded as too extensive to permit satisfactory repair and the concrete containing the defect shall be broken out and replaced.

## Repair Workmanship

The repair mortar shall be pre-shrunk by mixing it to a plastic consistency as far in advance of its use as possible. Trial mixes shall be made and aged to determine the longest period the mortar’s use can be delayed while retaining sufficient plasticity to permit good workmanship.

Immediately prior to the application of the mortar, the damp surface of the area to be repaired shall be scrubbed thoroughly with a small quantity of neat cement ground, using a wire brush. Remaining loose sand particles shall be swept away immediately before application of the mortar.

In applying the mortar, it shall be compacted into the space to be filled, care being taken to eliminate air pockets and to secure bond at the edges. The surfaces shall be shaped and finished to correspond with adjacent surfaces of the pipe.

The newly repaired surfaces shall be kept damp for 24 hours after the repair is completed. A membrane coating of an approved white-pigmented sealing compound shall then be applied.

Epoxy resin as bonding agent shall be used as a in the manner prescribed by the manufacturer. The prepared area shall be primed with the epoxy resin compound, care being taken to insure intimate contact with the base material. Mortar shall be applied before the epoxy resin compound sets.

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# Concrete Injection

To repair cracks in concrete and if in the Contractor’s opinion normal concrete repair methods as described above are deemed not to succeed, epoxy injection resin shall be applied in order to effectively seal the crack to protect the reinforcement and to monolithically weld the structure together.

Before any injection application the cracks to be injected shall be examined carefully to find the best injection method and material. Remedial of any further damages on the concrete structure caused by wrong injection material or injection method shall be borne by the Contractor.

Injection material shall have the following characteristics:

* Low viscosity;
* High modulus;
* High penetration ability;
* High tensile and bond strength and durability;
* Non-shrinkable;
* Creating permanent, high-strength bonds between concrete surfaces when fully cured;
* Allowing for the normal transfer of loads designed into the original structure;
* Creating an impervious seal to air, water, chemicals;
* Good workability.

## Equipment

For the equipment used to inject the resin, the Contractor shall meet the recommendations of the resin injection material manufacturer and the following requirements:

1. Equipment shall have the capacity to automatically proportion the material components within the mix ratio tolerances set by the resin materials manufacturer.
2. Equipment shall have the capacity to automatically mix the resin component materials within the pump and injection apparatus. The Engineer will not allow batch mixing.
3. Equipment shall have the capacity to inject the resin under controlled variable pressures up to 1.4 MPa, with a pressure gauge mounted at or near the nozzle to indicate the actual working pressure.

## Injection Personnel Qualifications

Only personnel trained in performing injection work similar to that works required for the project shall carry out the resin injection of cracks in concrete. The Contractor shall provide an on-site Engineerfor the resin injection work who is sufficiently qualified certified by the manufacturer of the resin injection material as having the necessary competence to accomplish the epoxy injection work in a satisfactory and safe manner in compliance with these Specifications.

## Crack Surface Preparation and Cleaning Requirements

The area surrounding the cracks shall be cleaned of all deteriorated concrete, efflorescence and other contaminants detrimental to the adhesion of the surface sealing resin compound. Clean the interiors of the cracks with air under sufficient pressure to remove loose materials entrapped within the crack including efflorescence.

## Sealing Cracks for Epoxy Injection

After cleaning, injection port holes shall be drilled using a swivel drill chuck and hollow drill bits, including a vacuum attachment which will remove dust and debris generated during drilling. The spacing of the injection port holes shall be determined by the size of the crack and the depth of the crack in the concrete substrate. The actual spacing of injection ports shall be determined by field trials. The holes shall be drilled to the necessary depth, exercising care in aligning the hole along the plane of the crack so that the hole follows the crack for the full depth. Injection ports shall be inserted in the drilled holes, allowing for a small reservoir below the injection port.

After cleaning the cracks and drilling the injection port holes, the crack surface and the injection ports shall be sealed with suitable epoxy.

## Epoxy Injection

The resin shall be injected in accordance with the resin manufacturer's instructions and chosen equipment. The actual injection procedures and pressures shall be determined in field trials, based on crack widths and depth into the substrate and sufficiency of the results.

The injection pressure shall be limited in order to avoid additional stressing of the crack, hydraulic lifting, rupturing of the cracked substrate, or further elongation of the crack.

Injection on very cold or hot concrete substrate or injection during cold or extremely hot weather shall be avoided.

When injecting resin against a head of water the cracks shall be sealed special high-mod epoxy gel adhesive to prevent water blowouts while injecting.

## Cleaning After Epoxy Injection

The concrete surface areas shall be cleaned of excess epoxy materials and injection ports after completing the epoxy injection work. Cleaning shall be accomplished in a manner which will not damage the concrete by scraping, light sand blasting, grinding, use of solvents, or any other appropriate method approved by the Engineer. Excess materials shall be cleaned so that no epoxy material or injection ports extend beyond the plane surface of the concrete.

## Acceptance

Failed injection work shall be corrected as necessary at no expense to the Contracting Authority. Additional injection ports shall be installed as required to achieve satisfactory reinjection of epoxy resin.

After the epoxy injection work is completed and accepted, the core holes shall be filled with an epoxy mortar consisting of one part by volume epoxy injection resin and four parts by volume clean, dry sand.

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# Steel Reinforcement

The Contractor shall carry out the works described in accordance with the appropriate standards or equivalent local or international standards. Local standards for reinforcement shall comply with EN 10080 (Steel bars for reinforcement of concrete).

## Design Requirements

Pertaining to Sub-clause 6.2 Design Concrete Requirements, in accordance to EN 1992:

* Minimum reinforcement shall be used;
* Steel bar size has to be limited, and
* Steel bar spacing has to be limited.

## Types and Quality and Storage of Reinforcement

Steel reinforcement (RF) for concrete shall consist of ribbed steel bars or ribbed steel wire fabric, except where otherwise shown. Quality of reinforcement steel and steel wire fabric shall be in accordance with DIN 488.

Reinforcement steel shall be chosen in accordance to EN 1992. The following strength classes shall apply according to EN 10027-1 and EN 10027-2: [new]

* Steel bars: B 420 S and B 500 S
* Steel wire fabric: B 500 M

The Contractor shall submit reinforcement detail drawings and calculations to the Engineer for his approval.

The Contractor shall prepare test specimens of steel reinforcement to be used in the Works. Test specimens shall be taken in the presence of the Engineer and shall be of a size sufficient to carry out the tests as described below. They shall be tested in an approved laboratory and the certified copies of the results of the tests shall be submitted to the Engineer. The specimens shall be tested for bending and tensile properties and the wire fabric also for weld shear strength. The methods and requirements for testing shall be carried out in accordance with the applicable Technical Requirements of DIN 488. No steel reinforcement shall be used in the Works until the testing results have been approved by the Engineer. If ordered by the Engineer, test procedures shall be repeated at the Contractor's expense for any new supply of reinforcement during the course of the Works.

Storage of reinforcement shall be on racks or supports clear of the ground. Different types and sizes of reinforcement shall be kept separate.

## Prestressing Steel

Quality of prestressing steel shall comply with BS 5896 “Specification for high tensile steel wire and strand for the prestressing of concrete" or BS 4486 “Specification for hot rolled and hot rolled and processed high tensile alloy steel bars for the prestressing of concrete” or other accepted standards. prEN 10138 shall be considered as well.

Prestressing steel shall be chosen in accordance to EN 1992. The following strength classes shall apply for wires and strands according to prEN 10138 and EN 10027-1:

* Low relaxation prestressing wire Y 1670
* Low relaxation prestressing wire Y 1770
* Low relaxation prestressing wire Y 1860
* Low relaxation prestressing wire Y 1960
* Low relaxation prestressing wire Y 2060

All wire, strand or bars shall be assigned a lot number and tagged for identification purposes before shipment. Anchorage assemblies to be shipped shall be likewise identified. Reels of pre-stressing strands stored on the pre-stressed plant yard and intended for the use in the works shall be stored off the ground and protected from the weather by means of an approved cover.

The manufacturer shall supply typical curves obtained from mill tests of the material furnished for use in checking stresses by means of observed elongations. In addition, the manufacturer of the strand shall furnish affidavits certifying as to the required properties. Where the Engineer intends to require non-destructive testing of one or more parts of the structure, special specifications will specify the required details of the work.

All of the materials specified for testing shall be furnished without cost to the Contracting Authority and shall be delivered in time for tests to be made well in advance of anticipated time of use. All samples submitted shall be representative of the lot to be furnished and in the case of wire or strand, shall be taken from the same master roll.

The following described samples shall be selected from each lot of material by the Engineer.

1. Pre-tensioning Method. For pre-tensioning strands, samples consisting of two pieces, one at least 1 m and one approximately 300 mm long, shall be furnished for each shipment, each strand size, and each heat number, per 5 reels or part thereof, of regular or high strength strand;
2. Post tensioning Method. The following lengths shall be furnished:

* For wires requiring heading - 1.5 m
* For wires not requiring heading - Sufficient length to make up one parallel-lay cable 1.5 m long consisting of the same number of wires as the cable to be furnished
* For strand to be furnished with fittings -1.5 m between near ends of fittings
* For bars to be furnished with wedge anchors -1.5 m between faces of anchor plates

1. Anchorage Assemblies. Two anchorage assemblies shall be furnished complete with distribution plates of each size or type to be used if anchorage assemblies are not attached to pre-stressed steel samples.

## Bending and Cutting Schedules

The Contractor shall prepare for his own use bar bending schedules and bar lists, cutting schedules and sheet lists for wire fabrics for each individual structure from the information given in the approved working Drawings and in the Technical Requirements, and shall be responsible for ensuring that correct information is given when ordering reinforcement. Copies of these schedules, lists and orders shall be submitted to the Engineer for his approval. Steel bar supports shall be included in the bending schedules.

The approval of the bar bending and cutting schedules, list, and orders shall not relieve the Contractor of his responsibility to execute the reinforcement fixing in accordance with the drawings and/or according to the requirements specified in EN 1992.

## Protection and Cleaning

Reinforcement shall be protected at all times from damage, and when placed in the structure shall be free from dirt, loose mill scale, rust scale, paint, oil or other foreign substance. All reinforcing steel shall be carefully cleaned of all set or partially set concrete, shutter oil or paint which may have been deposited during the construction of adjacent works.

## Bending of Bars

Steel reinforcement shall be cut from straight bars free from kinks and bends or other damage and shall be bend cold by experienced competent workmen. Bars of diameter greater than 12 mm shall be bent in a bending machine designed for the purpose and approved by the Engineer. Any reinforcing bar that has already been bent shall not be re-bent at the place of the previous bend.

## Cutting of Wire Fabrics

Wire fabric reinforcement shall be cut straight from the sheets. The use of off-cuts in the Permanent Works will not be permitted.

## Lapping of Bars and Wire Fabrics

Lapping bars and wire fabrics is permitted when necessary and approved by the Engineer. No welding of reinforcement shall be carried out unless authorised by the Engineer, welding and testing for reinforcement shall comply with the requirements specified in ISO 17660.

Unless otherwise specified, lap length of bars shall be at least 50 times the diameter of the larger bar, and laps shall be positioned in a staggered pattern.

Laps on adjacent section of wire fabrics shall generally be carried out as follows:

* End to end by lapping the two pieces one full mesh (measured from the ends of the longitudinal wires in the other piece) and securing the two pieces together with wire ties placed at intervals of about 450 mm.
* Side by side by placing the two selvage wires (the longitudinal wires at the edges of the fabric) one alongside and lapping the other, and by securing the two pieces together with wire ties placed at intervals of about 900 mm.

## Fixing of Reinforcement

All reinforcement steel shall be accurately placed and fixed in position and retained in that position during the placing of the concrete.

Spacer blocks for holding the reinforcement from contact with the forms, or adjacent reinforcement, shall be of dense precast concrete blocks of approved shapes and dimensions. The blocks shall be fitted with a semi-circular hollowing and double bent poured-in binding wires. The water tightness of these blocks must be at least similar to the concrete into which they are concreted. The use of pebbles, pieces of broken stone or brick or other materials will not be permitted.

Steel shall be bound and tied in its correct position using steel wire. Apart from any other requirement, the reinforcement, the reinforcing steel shall be fixed in such a manner that it will support its own weight and any loads which may be imposed upon it during construction without displacement, deflection, or movement of any kind.

In slabs provided with two or more layers of reinforcement the parallel layers of steel bars shall be supported in position by the use of steel chairs. Spacer blocks shall be placed at each chair to support the layers of reinforcement from the blinding concrete or shuttering.

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The distance between any two parallel bars except at laps shall not be less than 5 mm greater than the nominal aggregate size.

All reinforcement projecting from construction joints or likely to be exposed to the weather for long periods before concreting is commenced shall be covered with polythene blinding tape, cement grout or other materials to the surrounding concrete. Should in spite of these precautions rust staining occur on any permanently visible surfaces, it shall be removed at once to the satisfaction of the Engineer.

To avoid reinforcement projecting from construction joints reinforcement boxes shall be used to connect reinforcement at construction joints wherever possible. Reinforcement boxes and covers shall be made of galvanised or black sheet steel.

## Thickness of Cover

The concrete cover to the nearest reinforcement exclusive of plaster or other decorative finish and concrete blinding shall be accordance with EN1992 unless otherwise stated in the Technical Requirements for the relevant structure. [G16.7, paragraph 5]

The thickness of cover for the reinforced concrete shall be as described below:

1. For concrete faces in permanent contact with water or sludge: 5 cm
2. For concrete faces not in contact with water or sludge but exposed to the atmosphere: 5 cm
3. For concrete faces not exposed to the atmosphere and not in contact with water or sludge:

* For beams and columns: 4 cm
* For slab reinforcement: 3 cm

or the same as the diameter of the largest steel whatever is greater.

## Tolerances

* For member with thickness < 60 cm: ± 1 cm
* For member with thickness > 60 cm: ± 2 cm

## Approval before Concreting

All reinforcement, after having been fixed in position, shall be inspected and approved by the Engineer before any concrete is placed. Any concrete placed contrary to this requirement shall, if ordered by the Engineer, be removed together with the reinforcement and replaced by the Contractor at his own expense.

# Pre-stressed Concrete

## Sustainability of Pre-stressed Concrete Structures

Sustainability of pre-stressed concrete structures shall be guaranteed by proper design and execution. In particular design and execution shall consider the following risks. The Contractor shall prove to the Engineerhis measures to achieve sustainable structures by prevention of:

* Tendon corrosion and eventually tendon breakage;
* Uneven shim stack heights on the anchor-heads;
* Spalling and cracking of concrete beneath the anchor-head base plates;
* Free water in the bottom grease caps;
* Poorly drained top anchorage ledges;
* Absence of filler grease, and
* by minimizing tendon relaxation losses.

Prestressed concrete structures shall comply with EN 1992respectively with the requirements for pre-stressed concrete according to EC2.

## Tendons

Quality and material of prestressing steel is described in these Technical Requirements. In generally, for tendons the following requirements shall apply:

1. Type homologation is required;
2. Requirements on strength, deformation and fatigue resistance have to be fulfilled by

* proper choice of system (pre- or post-tensioning, bond or unbond)
* design of concrete strength, profiles and dimensions fit for the purpose of the structure in dependence of chosen system
* limitation of ultimate strain
* proper anchorage system and location

1. force transmission has to be guaranteed.

### Tendon Fabrication and Supply

* No tendon containing splices shall be used;
* No welding shall be permitted on or near tendons, nor shall any heat be applied to tendons. Any tendons which have been affected by welding, weld spatter and/or heat, or otherwise damaged shall be rejected and shall be replaced by the Contractor at its expense;
* A durable metal label, on which shall be stamped the length of the tendon and the coil number of the wire or strand used, shall be tied to each tendon;
* The tendons shall be supplied in coils of a sufficiently large diameter so that they are straight as they unwind from the coils. Kinked or damaged tendons will not be permitted.

### Storage and Cleaning

* Coils of tendons shall be protected from the weather, chlorides, dirt, mortar, loose rust, tar, paint, oil or any other deleterious matter and other aggressive substances, and shall not be placed in direct contact with the ground;
* Components shall be handled and stored so that mechanical damage and detrimental corrosion are prevented. They shall be kept free from chlorides, urea;
* All lubricant used in the drawing of the tendon shall be thoroughly removed by a suitable degreasing agent. No rust shall be permitted on the tendons.

### Testing Requirements for Tendons

Manufacturer's Test Data

Testing of wire or strand will be carried out in accordance with the requirements of EN 10002.

Each delivery of materials shall be accompanied by documentation showing the lot numbers from which each coil is taken, together with the relevant test certificates, which shall include the data on chemical composition. All coils of tendons shall be capable of being identified with the test certificates.

The information provided by the manufacturer or supplier shall demonstrate that each coil complies with the Specification and with the stated properties submitted.

For each coil used in the Works the Contractor shall also provide the following information obtained from the manufacturer:

* Breaking force;
* Yield strength and elongation (based on lots representing not more than five manufactured lengths);
* Load-strain relationship (based on lots representing not more than five manufactured lengths), stating the measured cross-sectional area and the elongation per 10 m at 70% and 80% of nominal minimum breaking force;
* 1,000 hour relaxation loss at 70% and 80% of nominal minimum breaking force;
* Plot of the load-strain relationship which is representative of the tendon material proposed for use in the works.

**Field Tests to Confirm Stressing Calculations**

* The Contractor shall confirm the validity of his predicted elongation’s by carrying out field tests on lengths of strand not less than 10 m in length. This would normally be the stressing of an undeflected strand in a structure;
* One length of strand from each coil proposed for use in the Works shall be stressed to confirm the load-elongation results provided by the manufacturer. The sampling and stressing of this strand shall be carried out in the presence of the Superintendent;
* During stressing of the test strands, measurements of elongation shall be taken at incremental jacking forces up to 80% of the minimum breaking force to establish the full load-strain relationship for the test strand which shall then be compared with that provided by the manufacturer;
* If the measured elongation (including extrapolated component for the pull-up force) agrees with the value obtained from the manufacturer's data sheet to within ±2% then the manufacture's test data may be used for predicting elongation’s for all strand taken from that coil;
* If the measured elongation is not within ±2% of the value predicted from the manufacturer's test data, the Contractor may revise his calculations on the basis of the field tests, provided he can demonstrate that the total prestress forces will be within the limits.

### Corrosion Protection of unbounded Tendons

Tendons shall be lubricated and protected against corrosion by a properly applied coating of grease or other approved material. Minimum weight of coating material on the prestressing strand shall be not less than 3 g of coating material per m and per 1 mm diameter of the strand. The amount of coating material used shall be sufficient to ensure essentially complete filling of the annular space between the strand and the sheathing. The coating shall extend over the entire tendon length. Coatings shall remain ductile and free from cracks at the lowest anticipated temperature and shall not flow out from the sheath at the maximum anticipated temperature. Coatings shall be chemically stable and non-reactive to the tendon, the concrete and the sheath.

## Anchorage

Stressable anchorage, fixed anchorage and couplings shall develop almost 100% of the actual ultimate strength of prestressing steel without exceeding anticipated set. Dynamic tests shall be performed on the whole system of anchorage and prestressing steel as specified below.

Anchorage castings shall be nonporous and free of sand, blow-holes, voids and other defects. Damaged or used anchorage components shall not be permitted.

### Types of Anchorage

For a wedge type anchorage, the wedge grippers shall be designed to preclude premature failure of the prestressing steel due to notch or pinching effects under static test load conditions to determine yield strength, ultimate strength and elongation of the tendon.

An anchorage of any other type than described below may be used provided the basic requirements noted herein are demonstrated by an acceptable test program.

### Anchorage for Bar Tendons

**Stressable anchorage** for bar tendons shall consist of an anchor-plate casting with a wedge seat. A reusable pocket former shall provide a recess for the stressing jack. Special care shall be given to the corrosion protection between the anchor-plate and the duct.

**Fixed anchorage** for bar tendons shall be similar to stressable anchors (preseated and secured anchoring wedges).

### Anchorage for Multiple Strand Tendons

**Stressable anchorage** for multiple strand tendons shall consist of a steel anchor head with different types of bearing plate and trumpet assemblies. Strands shall anchored individually by wedges which, by means of the stressing unit, are hydraulically seated in the anchor head for equal gripping. The wedges shall be self-centering on the anchorage body.

**Fixed anchorage** for multiple strand tendons shall be either similar to the stressable anchorage or alternatively, depending on the number of strands either with button heads on strands or of the loop-type or whereby each strand is provided with a short loop outside the duct. The loops shall be formed on the construction site by means of a special light tool.

**Coupling anchorage** for multiple strand tendons shall be used when structural components are concreted in sections and tendons have to be connected to already stressed ones, anchored at a construction joint. The anchor head shall accommodate an equal number of strands from both sides and for safe gripping, wedges and springs shall be preassembled. The second stage strands shall be coupled by inserting the chamfered strands into the anchor holes with special spring fixed wedges. On each strand the insertion length shall be marked in order to have a visual control that it is properly positioned.

For cylindrical structures (water tanks, digester tanks, large pipes or dome shells) that require circumferential post-tensioning non-fixed coupler may be applied. The tendon anchorage shall consist of an anchorage block with wedge holes on both sides to accept bars or greased and sheathed strands. The strands shall overlap in the block (belt-buckle principle).

### Anchorage for Multiple Wire Tendons

**Stressable anchorage** for multiple wire tendons shall consist of a button head by which each wire shall be fixed in a compact anchor head. The button head shall be cold-upset by special machines. After prestressing the anchor head shall be blocked either by a screwed-on lock nut or by shims inserted between anchor-head and bearing plate.

**Fixed anchorage** for multiple wire tendonsshall be either similar to the stressable anchorage or alternatively of the fan-type. The fan-anchor partially transmits the forces by bond and partially by an anchor plate.

**Coupling anchorage** for multiple wire tendonsconnecting two tendons shall consist essentially of two stressable anchorage coupled by a rod or a coupling sleeve.

### Requirements

Anchorage shall meet the following requirements:

An anchorage for bonded tendons tested in an unbonded state shall develop 95% of the actual ultimate strength of the prestressing steel, without exceeding anticipated set at time of anchorage. An anchorage which develops less than 100% of the minimum specified ultimate strength shall be used only where the bond length provided is equal to or greater than the bond length required to develop 100% of the minimum specified ultimate strength of the tendon. The required bond length between the anchorage and the zone where the full prestressing force is required under service and ultimate loads shall be sufficient to develop the specified ultimate strength of the prestressing steel. The bond length shall be determined by testing a full-sized tendon. If in the unbonded state the anchorage develops 100% of the minimum specified strength it need not be tested in the bonded state.

An anchorage for unbonded tendons shall develop 95% of the minimum specified ultimate strength of the prestressing steel with an amount of permanent deformation that will not decrease the expected ultimate strength of the assembly.

The minimum elongation of a strand under load in an anchorage assembly tested in the unbonded state shall be not less than 2% when measured in a gauge length of 3 m.

### Anchorage Reinforcement

Spiral and other reinforcement specified by the manufacturer as being required as part of the anchorage devices shall be incorporated in the works in accordance with the sizes and dimensions recommended by the manufacturer for the prestressing system to be used.

## Sheathing

In generally, for sheathing the following requirements shall apply:

* Type homologation is required;
* The sheathing and all splices shall be mortar tight;
* Sheathing shall be stored off the ground and protected from the weather at all times;
* Profile of sheathing has to guarantee sound force transmission;
* The Manufacturer's test values for the friction coefficients of the proposed sheathing shall be confirmed by the Contractor;
* Sheathing shall have sufficient strength and durability to resist damage and deterioration during fabrication, transport, storage, installation, concreting and tensioning.

### Specific Requirements

Sheathing for Bonded Post-Tensioned Tendons

* Sheathing shall be strong enough to retain its shape, resist unrepairable damage during production, and prevent the entrance of cement paste or water from the concrete;
* Sheathing shall be securely fixed throughout its length, by methods that will hold it in position and resist movement due to flotation, concrete placement or vibration and do not damage or deform it;
* Sheathing material left in place shall not cause harmful electrolytic action or deteriorate;
* The inside diameter shall be at least 6 mm larger than the nominal diameter of single wire, bar or strand tendons; or in the case of multiple wire, bar or strand tendons, the inside cross-sectional area of the sheath shall be at least twice the net area of the prestressing steel;
* Sheaths shall be capable of transmitting forces from the grout to the surrounding concrete;
* Sheaths shall have grout holes or vents at each end and at all high points except where the degree of tendon curvature is small and the tendon is relatively level.

Sheathing for Unbonded Tendons (Post-Tensioning System)

* Sheathing shall be of material which is not reactive with concrete, coating or steel. The material shall be waterproof;
* The sheath shall have a coefficient of friction with the strand of less than 0.05;
* Tendon covering shall be continuous over the unbonded length of the tendon and shall prevent the intrusion of water or cement paste and the loss of the coating material during concrete placement;
* The sheaths shall not become brittle or soften over the anticipated exposure temperature and service life of the structure;
* The minimum wall thickness of sheaths for non-corrosive conditions shall be 1 mm;
* The sheathing shall have an inside diameter at least 0.8 mm greater than the maximum diameter of the strand;
* Joints between the sheathing and any other part of the prestressing system shall be effectively sealed to prevent entry of mortar, dust, water or other deleterious matter.

## Installation of Pre-Tensioning Systems

### Pre-Tensioning Anchorages Installation

Strand chucks for pre-tensioning shall be capable of anchoring the strand without slippage after seating. Length of grips and configuration of serrations shall be such as to ensure against strand failure within the vise jaws at stresses less than 95% of strand ultimate strength. Steel casings for strand vises shall be verified by the manufacturer as capable of holding at least 100% of the ultimate strength of the strand.

Devices used to deflect the strand to the required position shall be designed to minimise friction to the level consistent with the tolerances for strand tensioning. Strand shall be able to move freely over, under, or through the device.

Harped strands must be held in position by devices capable of supporting the load imparted from the tensioned strand without excessive deformation. Excessive friction in such devices can cause the strand tension to vary over the length of the bed. If a strand becomes pinched or otherwise caught in the device, strand breakage can occur.

Strand restraining devices should be designed for an appropriate factor of safety.

Each anchorage device shall be set square to the line of action of the prestressing tendon and shall be positioned securely to prevent movement during concreting.

The anchorage devices shall be cleaned prior to the placing of concrete.

### Pre-Tensioning Tendon Installation

* Tendons containing nicks, kinks, or former chuck grip marks shall not be used;
* Steel showing evidence of scale formation or which has become pitted shall not be used;
* Tendons shall be located as shown on the Drawings within a tolerance of ±5 mm. Suitable devices shall be provided so as to maintain the correct positioning of the tendons during placing of concrete;
* Care shall be used during placement of prestressing steel to avoid physical damage and contamination. Damaged strands shall be rejected;
* Particular care shall be taken that the tendons shall not come into contact with the oiled surface of the forms or be otherwise soiled. Any oil etc. found on the tendons shall be removed. Then the cleaned strand shall be restored to its original condition prior to concrete placement;
* The prestressing steel shall be inspected for broken wires and other damage after placement into the bed;
* Any damaged prestressing steel in the bed shall be removed and replaced before the stressing operation begins;
* Prestressing steel that has been stressed in a draped position shall not be reused.

## Installation of Post-Tensioning Systems

### Grout Holes Installation

Grout holes shall be provided at both ends of the ducts and shall be at least 10 mm diameter. The ends of the grouting holes shall be equipped with a plug, valve or similar device capable of withstanding a grout pressure of 1 MPa without loss of water or air. Additional vents with plug valves shall be provided at high and / or low points of the duct to bleed air or water and to ensure the duct is completely filled after grouting.

### Tendon Installation

Special uncoilers or hydraulic winches shall be used to properly install the tendons in the structure. Tendons shall be handled with care, and be installed through the sheathing in such a manner as to avoid damage or contamination to either the tendon or sheathing.

Strands may be pushed into the sheathing either before or after casting the concrete. The mechanical pushing equipment shall provide relatively high push speed and shall be equipped with a length measurement meter with automatic shut-off and an electric push-button switch at discharge end for locking into place and length correction.

Strands may be as well pulled into the duct onsite. In normal cases, the whole tendon i.e. all strands shall be pulled through simultaneous hydraulically winching the bundle with the winch cable. The winch cable shall be placed by threading steel or glass fibre wires through the sheathing. Winches shall offer control of speed and pulling force.

## Stressing Equipment

All stressing equipment shall conform to the requirements of (a), (b), or (e) below. In addition, all stressing equipment shall be calibrated in accordance with (c) below in order to give a correlation between the force applied to the tendon and the reading indicated by the pressure gauge.

* 1. The stressing equipment shall be a hydraulic jacking system which can be adjusted to automatically apply and sustain a predetermined load together with a pressure transducer built into the hydraulic system. Such transducer shall be connected to a digital readout and printer which shall provide an instantaneous readout and record of the applied load in pounds. The readout record shall provide a numerical value of the applied load. The jacking system used shall have the capacity to induce the required load. The jacking equipment shall contain pressure bypass valves that will permit pulling to a predetermined load which can be held while elongation checks are made. Use of this system shall be based on demonstrated accuracy and repeatability verified through comparison with loads indicated by either an independent load cell or proving ring;

Continued use of the equipment shall be contingent upon the satisfactory performance of the equipment in service as determined under the requirements of (d) below;

* 1. The stressing equipment shall be a hydraulic jacking system as described in (a) above with a load cell built directly into the hydraulic jack and connected to the digital readout and printer instead of the pressure transducer. Continued use of the equipment shall be contingent upon the satisfactory performance of the equipment in service as determined under the requirements of (d) below;
  2. Prior to their use, all jacking systems shall be calibrated. Calibration shall be repeated at intervals not exceeding 12 months. Recalibration during the intervals may be required by the Engineer as described hereinafter. Calibrations and recalibrations shall done by a qualified calibration agency;

Gauges, jacks and pumps shall be calibrated as a system in the same manner they are used in tensioning operations with the cylinder extension in the approximate position that it will be in actual use at final jacking force. Calibrations should cover the load ranges that will be used during production. A certified calibration curve shall accompany each tensioning system. Load readings can be used directly if the calibration determines a reading is within 1.5% tolerance of actual load. Calibration of load cells or proving rings used to calibrate jacking systems shall be on compression testing equipment that has been checked by an independent agency accredited for this kind of testing within the preceding 24-month period;

If, while work is in progress, any jack or gauge appears to be giving erratic results, or if the jack force and elongation do not compare within specified limits and differences cannot be justified, recalibration shall be required. Recalibration shall also be required after internal jacking system repairs or when gauge and jacking units are switched;

* 1. Any calibration or recalibration shall be done in accordance with EN 10002. After calibration or recalibration has been completed, a certificate shall be prepared and signed by the person in responsible charge of the verifications as outlined;
  2. The accuracy of the jacking and recording system shall be verified by the Contractor a minimum of once each week during stressing operations by either an independently calibrated load cell or a proving ring. The load reading from the recording system shall agree within 1.5% of the load indicated by the load cell or proving ring.

Pressure gauges shall comply with the requirements for industrial gauges. Test certificates showing such compliance shall be kept in the site office of the Contractor.

Jacks for multi-strand tendons shall be equipped with:

* Internal strand guide tubes with automatic strand gripping and releasing devices;
* A check valve which shall hold the pressure in the event of hydraulic failure;
* Special devices for power seating all wedges simultaneously.
* Jacks also shall allow for;
* Bleed-back to achieve full utilisation of the maximum allowable stresses along the tendon length;
* Detension of already pre-stressed tendons.

## Stressing Records

The Contractor shall keep records of the stressing operation as follows:

* Identification number of dynamometers, gauge, pump and jack;
* Identification particulars of tendons;
* Initial forces (or pressures) when tendons are marked for measurement of elongation;
* Final forces (or pressures) and elongation obtained on completion of tensioning;
* Elongation remaining after anchoring;
* Elongation obtained at intervals during tensioning, together with corresponding forces (or pressures);
* Concrete stress shall be controlled at the time just after transferring of prestress and at service load after all losses

## Pre-Tensioning Stressing

### Pre-Stressing

The stressing operations shall consist of the application of the final load required by the plans and adjusted for abutment rotation, bed shortening, anchorage header movement, anchor set, slippage, live end seating and any other element as applicable for the type of bed and anchorage being used.

Also, the final load required by the Drawings shall be adjusted when the temperature differential between the ambient temperature at time of stressing and the expected concrete temperature at time of placement is greater than 24°C The load shall be increased 0.5% for each 3°C increment between the ambient temperature at time of stressing and the expected concrete temperature at time of placing. When the expected concrete temperature at time of placing is below the ambient temperature at time of stressing, no adjustment to the final load shall be made.

The stress in the prestressing steel shall not exceed the stress allowed.

Compensation for temperature differential and abutment rotation are not required for self-stressing beds. However, the final load shall be adjusted for the effects of bed shortening due to the load from all the strands.

If the placement of concrete is delayed for more than 7 days after the completion of the stressing operation, the Contractor shall check and adjust the final strand load as necessary prior to the placement of concrete.

The stressing methods, in general, consist of stressing to the loads indicated by the jacking system, or stressing to the required load while monitoring the elongation of the prestressing steel.

Stressing shall be accomplished by either single strand stressing or multiple strand stressing, and shall be symmetrical about the vertical axis of the structure.

### Single Straight Strand Stressing

When single straight strand stressing is used, the prestressing steel shall be tensioned until the required final load is attained. The loads indicated by the jacking system shall control the tensioning process. Two-stage stressing, consisting of an initial load and final load, may be used. The initial load, if used, shall be between 5% and 25% of the final load.

### Multiple Straight Strand Stressing

Each strand to be stressed in a group shall be individually brought to an initial uniform tension prior to being given their full tensioning. The amount of the initial load will be influenced by the length of the casting bed and the size of strands in the group to be tensioned. The minimum initial tensioning load shall be 5% of the required final load. The magnitude of this load may be increased if deemed necessary but shall not exceed 25% of the required final load. The strands shall then be stressed by multiple strand stressing to final load by pulling to elongation and checking against the jack load. The required elongation shall control the tensioning. The actual jack load shall agree within 5% of the computed elongation converted to load.

For uniform application of load to strands, the face of anchorage at final load must be in a plane parallel to its position under initial load. This shall be verified by measurement of movement on opposite sides of the anchorage and a check of its plumb position before and after application of the final load. During stressing, the anchorage shall be free to move without restraint.

### Draped Strand Stressing

Draped strands shall be tensioned by either of the following methods:

1. Partial Stressing and Subsequent Strains:

This method applies when the strands are tensioned through a combination of applied jack loads and strand uplift. To verify the final force, a load cell shall be placed between the stressing anchorage and anchor chucks at the dead end on at least two draped strands. Other methods as approved by the Engineer may be used to verify the final force in the dead end. The partially draped strand shall be brought to an initial tension using a force in the range of 5 to 25% of the required final stressing force. After application of the initial force, reference marks for measuring elongation shall be established.

A pre-calculated jacking force shall then be applied and elongations measured on a minimum of four strands. The average measured elongation shall agree within 5% of the theoretical elongation for the strand force measured by jack load, or the factors contributing to the difference shall be identified and corrected prior to proceeding. The load indicated by the jacking system shall control the tensioning for the pre-calculated load.

The required final force shall be obtained by raising the strand simultaneously at all pickup points or in an approved sequence as shown on the shop drawings. On each different bed set-up, after deflecting the strands to their final position, the final force shall be checked on two strands at the dead end of the bed. If the load is below the required stressing force by more than 5%, it shall be adjusted to the final load.

1. Final Stressing in Draped Position:

When the final stressing is performed in the draped position, the tensioning load shall be applied in two increments with the tendons being held in their draped positions. To verify the final force, a load cell shall be placed between the stressing anchorage and anchor chucks at the dead end on at least two draped strands. Other methods as approved by the Engineer may be used to verify the final force at the dead end. Each strand shall be brought to an initial tension of 5 to 25% of the final load prior to the application of the required final load.

After application of the initial load, reference marks for measuring elongation shall be established. The strands shall then be stressed to final load and the elongation measured. The load indicated by the jacking system shall control the tensioning for the initial and final loads.

The measured elongation shall agree within 5% of the theoretical elongation for the strand force measured by jack load, or the factors contributing to the difference shall be identified and corrected prior to proceeding.

When the jacking is performed at one end of the bed, the applied load shall be checked on two strands at the other end of the bed. If the load on the end opposite the jacking end is below the required value by more than 5%, the load shall be adjusted to the required final load.

### Wire Breakage

Wire breakage shall be limited to 2% of the total area of the strands in any structure and verification that breakage is not indicative of a more extensive distress condition, otherwise all stranding shall be rejected. Individual strands with more than one wire failure shall be replaced.

### Strand Chucks and Splice Chucks

Chucks shall be used as complete units and shall be cleaned, inspected and lubricated between each use. Care should be taken to avoid improper fit and seating of wedges on the strands. The wedges and housing shall be compatible and made for the specific type and size of steel being used.

Wedges that become worn, cracked, deformed, or that allow slippage in excess of 1 cm shall not be used and shall be discarded. Only components from the same manufacturer shall be used to make up chucks and to provide proper wedge fit.

One patented splice per strand will be permitted subject to the following:

1. Splices shall be located outside the concrete structures
2. Strands which are being spliced shall have the "lay" or "twist" in the same direction.

### Cleanliness of Prestressing Steel

After stressing operations are complete, the prestressing steel shall be inspected for any evidence of contamination. Steel shall be free of deleterious materials such as grease, oil, wax, dirt, paint (except that used for marking identification) or other similar contaminants. Any contaminants detected shall be removed from the steel before proceeding with fabrication activities.

## Detensioning

Transfer of prestress shall not be carried out until the concrete has attained the specified transfer strength as proved by standard test cylinders, manufactured and cured for this purpose, however not less than 30 MPa.

The Contractor shall verify the release strength by compressive strength cylinder tests or other approved means no later than 24 hours after casting, and every 24 hours thereafter until release strength is obtained.

For structures cured using accelerated curing, the prestressing force shall be released immediately after terminating curing. For structures cured using methods other than accelerated curing, the prestressing force shall be released within 24 hours of verifying release strength by compressive strength cylinder breaks, or other approved strength gain monitoring system, unless the required time for release occurs on a weekend or holiday.

Structures cured using methods other than accelerated curing, but which induce heat into the concrete shall be detensioned before a concrete temperature drop occurs of more than 30°C, from the concrete temperature at the time release strength was verified. The Contractor shall provide means and methods of insuring compliance with the above requirements of monitoring concrete temperature.

### Method of Stress Transfer

In all detensioning operations, the prestressing forces must be kept nearly symmetrical and must be applied in a manner that will minimise sudden shock or loading. Forms, ties, inserts, or other devices that would restrict longitudinal movement of the structures along the bed shall be removed or loosened. Hold-downs of draped strand profiles shall be removed at the appropriate time for the specific structure.

Hold-downs for structures with draped strands shall be released prior to releasing the stresses at the anchorages, unless the hold downs are free to move longitudinally. If the latter is the case, the hold-downs may be released subsequent to release of the anchorage stress.

Dormant strands shall be cut prior to releasing any fully tensioned strands. Fully bonded strands shall be released next, followed progressively by strands having the minimum length of tubular sheathing through to those strands having the maximum length of tubular sheathing. The Contractor may propose alternative detensioning patterns to suit his particular operation. The method of the stress transfer to be used by the Contractor shall be specified either in construction submittals or shop drawings to be submitted to the Engineer for approval.

Prestressing forces shall be transferred to the concrete by multiple strand release, as follows:

All the strands shall be detensioned simultaneously by hydraulic dejacking or by other approved mechanical means. Flame releasing shall not be allowed. The total force is taken from the header by the jack, then released gradually. The overstress required to loosen the anchoring devices at the header shall not exceed the force in the strand by 5%. Shock releases shall NOT be permitted; if tendons should fail suddenly, the Engineer may order load testing of any structures so affected. Special care shall be taken to ensure that the force in any tendon never exceeds 85% of the specified ultimate tensile strength of the tendon.

### Trimming Strands

After the transfer of prestress, severed tendons shall be trimmed flush with the end of the structure using abrasive disc grinders without damaging the concrete. Electric arc welders or oxygen flame trimming shall not be used.

After trimming and within 12 hours of detensioning, the ends of the tendons and the area immediately adjacent to the tendons shall be painted with an epoxy compound to provide a film thickness at least 0.3 mm dry or 0.6 mm wet. A minimum of two coats shall be applied.

## Post-Tensioning Stressing

Before any stressing operation the Contractor shall ensure that sheathings are clear of obstructions and allow free movement of the tendons. The Contractor shall prevent damage to the sheaths caused by any water freezing in the sheaths prior to grouting.

At least 1 week prior to stressing the Contractor shall provide detailed calculations of extensions corresponding to the required tension force at the anchorage, as shown on the drawings, to the Engineer.

These calculations shall be based on the secant modulus determined from the test certificates or test samples and the expected jack and anchorage friction.

Furthermore the Contractor shall submit to the Engineer a stressing procedure plan for approval, stating all relevant stressing steps and stressing control measures like:

* Sequence of stressing;
* Bar protrusion at the anchorage before and after stressing to evaluate the effective elongation;
* Counter control for elongation during stressing operation;
* Gauge control for hydraulic pressure.

Particular attention shall be given to minimisation of seating losses.

Stressing shall not be carried out without 24 hours prior notice being given to the Engineer. The stressing operation shall be performed under the supervision of a competent person provided by the Contractor.

### Stressing Procedure

* The stressing operation shall be performed in accordance with best practice applicable to the particular system approved;
* The sequence of stressing shall be as shown in the stressing procedure plan and in the drawings;
* No tendons shall be stressed if they are at a temperature of 0oC or below. In addition, the air temperature must be 5oC or above;
* The tensioning force applied to any tendon shall be determined by direct measurement of the jack gauge reading and shall be checked by measurement of the elongation of the tendon;
* Under no circumstances shall the maximum jacking force exceed the rated capacity of the jacking equipment used or 85% of the specified minimum ultimate tensile strength of the tendon, whichever is the lesser;
* True extension of the tendon shall be considered to be the sum of the measured extension and the zero corrected value of the extension obtained by application of the initial tension minus the amount of pull-in at anchorages and anchorage movements (if any);
* Whenever the actual extension and the calculated extension differ by more than 5% the Engineer shall be notified;
* No structural structure shall be left partly stressed unless the drawings require the structure to be stressed in stages.
* After taking up the slack, the tendon shall be accurately marked at both ends and elongations or draw-in measured from these markings;
* Where tendons consist of a number of individual components each component shall be marked so that any slip may be observed;
* Where one or more components or tendons of a group stressed together slips during stressing operations, a compensating increase in the elongation of the remaining tendons of the group will be permitted provided that the jacking force does not exceed 85% of the minimum ultimate tensile strength of the remaining tendons;
* In the case of a tendon breaking or slipping after tensioning, so that the allowable tolerance specified above is exceeded, the tendon shall be released, replaced and re-stressed.

### Tensioning with one Jack

Unless otherwise stated on the Drawings, the tendons may be tensioned by means of one jack only. Tendons shall be marked for measurement of elongation at both the jacking end and the anchored end, and allowance shall be made for any draw-in of the tendon at the anchored end.

## Grouting

The durability of post-tensioned construction depends to a great degree on the success of the grouting operation considering that the hardened cement grout provides bond between concrete and tensile element as well as primary long-term corrosion protection (alkaline medium) for the prestressing steel. Advanced methods such as pressure grouting, post-grouting and vacuum grouting shall be applied preferably.

Tendons shall be grouted as soon as practicable, but not more than 48 hours after fully stressing the tendons.

### Preparation of the Duct before Grouting

* Anchorages shall be sealed to prevent loss of grout;
* The grouting duct shall be water tested for blockages and shall be capable of sustaining a pressure of at least 1 MPa without leakage. Any leaks shall be plugged;
* All surplus water shall be removed from the grouting ducts prior to grouting.

### Grout Materials and Properties

Grout for bonded tendons shall consist of a mixture of Portland cement and water unless the gross inside cross-sectional area of the sheath exceeds 4 times the tendon cross-sectional area, in which case a fine aggregate may be added to the mixture.

* Fly ash and pozzolanic mineral admixtures may be added at a ratio not to exceed 0.3 by weight of cement;
* Mineral admixtures shall conform to EN 480/934;
* Approved shrinkage-compensating material, which is well dispersed through the other admixture, may be used to obtain 5 to 10% unrestrained expansion of the grout;
* Admixtures containing more than trace amounts of chlorides, fluorides, zinc or nitrates shall not be used;
* Fine aggregate, if used, shall conform to prEN 12620;
* Grout shall achieve a minimum compressive strength of 17 MPa at 7 days and 34 MPa at 28 days. 2 cubes shall be taken from each day's grout material. Test cubes shall be made and cured in accordance with Sub-clause 1.6.6. (Concrete Testing);
* Grout shall have a consistency that will facilitate placement;
* Water content shall be the minimum necessary for proper placement;
* Water-cement ratio shall not exceed 0.45 by weight.

The bleeding of the grout shall not exceed 2% of the Volume 3-1 hours after mixing and shall not exceed 4% of the volume at any time. All separated water shall be absorbed within 24 hours. Bleeding shall be measured in a metal or glass cylinder with an internal diameter of approximately 100 mm and with a height of grout of approximately 100 mm. During the test the container shall be covered to prevent evaporation. At least one bleeding test shall be carried out for each day's grouting.

### Mixing and Pumping Equipment

Grout shall be mixed until a uniform colloidal consistency is produced. Mixing by hand, or by a tumbling action, will not be permitted.

Grout shall be mixed and pumped into place not more than 1 hour after the addition of cement to the mix.

Pumps shall be capable of continuous operation with little pressure variation, and shall have a system for recirculating the grout whilst actual grouting is not in progress. Pumps shall be fitted with a pressure gauge and shall be capable of delivery at pressures up to 1 MPa. The use of compressed air will not be permitted.

All equipment, especially piping, shall be maintained in a clean condition.

### Grouting

Grouting shall not be carried out while the air temperature is below 5°C, or while the shade temperature exceeds 32°C. A continuous, steady flow of grout shall be maintained until the duct is completely filled and pure grout issues from all vents and all entrapped air has been expelled.

The vents shall be progressively closed as required to ensure the complete filling of the duct. The grout pressure shall then be held at 0.7 MPa for 10 minutes. During this period bleed water shall be bled from the crest vents at 5 minutes and just prior to the end of the period. After this 10 minute period the inlet vent shall be closed in such a way as to hold the pressure in the duct at 0.7 MPa. If any leaks occur such that the pressure over the length of the duct cannot be maintained at 0.7 MPa, the grouting shall be stopped, the duct flushed clean with water and the leakage plugged before continuing with grouting.

The quantity of materials shall be such as to enable the completion of grouting of whole duct(s) (allowing 10% wastage) without interruption.

All vents and ends shall be kept closed until final setting of the grout has taken place.

All duct openings shall be inspected two or 3 days after grouting and topped up if necessary.

In the event of difficulties occurring due to a blockage which prevents a duct from being completely filled with grout the grouting shall be stopped, the duct flushed clean with water and the blockage removed before continuing with grouting.

### Trimming

After the grout has hardened sufficiently any vents or grouting tubes which extend to the surface of the concrete shall be cut off 25 mm below the concrete surface and the recess plugged with an approved concrete repair mortar.

Tendons shall not be cut until 5 days after grouting. The tendons shall be cut back to give a minimum of 25 mm cover on post tensioned structures.

Before concreting, the recesses shall be roughened lightly by abrasive blasting and a "wet to dry" epoxy shall be applied to the whole of the end faces in accordance with the manufacturer's instructions.

# Precast Concrete Structures Units

Buildings, pipeline manholes and cable manholes may be designed as precast concrete structures. Precast concrete units shall not be used for building water retaining structures.

Precast concrete structures pre-stressed, reinforced and not reinforced, shall comply with the Technical Requirements where applicable. The Contractor shall submit Working Drawings to the Engineer. If ordered by the Engineer, the Contractor shall also submit detailed calculations for precast structures according to the sections mentioned above.

Precast structures shall be manufactured either on the site or in a concrete factory approved by the Engineer.

The Contractor shall take all measures concerning the curing and protection of the units after fabrication.

Transportation of the units to the site shall be permitted only under of the following conditions:

* 28 days after fabrication, or
* after the required compressive strength specified has been reached.

Where the installation of precast structures in any particular structure is such that the faces of the units are to be left exposed either internally or externally, the exposed surfaces of the units as finished shall be uniform in colour and in texture. All cement, aggregates and other materials used in the manufacture of the units shall be obtained from the same approved sources throughout the period of manufacture.

Concrete for structures shall be placed and compacted by methods approved by the Engineer.

## Fabrication

Pre-cast concrete elements shall be cast in water tight, metal lined, timber moulds and shall be mechanically vibrated when cast. The pre-cast elements shall be removed from the moulds as soon as practicable and shall be kept damp for a period of at least 10 days. Any elements that show cracks or soft corners or surfaces shall be rejected. The method of storage and handling shall be such as to preserve true and even edges and corners. Any pre-cast element, which becomes chipped, marred or cracked before or during the process of placing, shall be rejected.

## Concrete Quality and Tests on Concrete

## Concrete Quality and Tests on Concrete

The concrete used in the manufacture of precast concrete units shall comply in every respect with these Specifications and the class of concrete required shall be in accordance with the requirements of EN1992.

The design, mixing, testing, curing and quality control of the concrete used in precast units shall be in accordance with these Specifications, Sub-clause 5.18Testing.

Shuttering and concrete finishes shall comply with these Technical Requirements.

## Cast-In Parts

The cast-in parts, such as lifting lugs, fasteners, jointing materials supporting structures, etc. shall be fixed in the positions as shown on the working drawings. Cast-in parts shall be free from rust, dirt or grease and shall be properly stored before using.

## Marking of Precast Structures

The date of casting and an identification number shall be marked on every precast structure.

The ends of unsymmetrical structures shall be clearly marked to indicate the manner in which they are to be oriented in the precast structure.

Temporary identifications and date of casting markings shall be scratched into the top surface of the member near an end immediately after screeding off.

The final marking shall be made by indelible marking material using letters approximately 75 mm high.

## Lifting, Handling, Stacking

Post tensioned precast structures shall not be lifted until 7 days after grouting.

No superimposed load shall be placed on a precast structure.

Temporary supports for precast structures shall be of timber covered with plastic to avoid staining of concrete surfaces. These bearers shall support the precast structures over their full width only at the positions at which they will be finally supported in the bridge.

## Transport, Storage and Erection

Prior to delivery to the site for erection the Contractor shall verify that each precast structure exhibits satisfactory workmanship and finish, and complies with the tolerances on dimensions and prestressing forces.

The Contractor shall submit detailed proposals for the erection of the precast structures in their permanent position to the Engineer at least two weeks before commencing this operation. [new]

At all stages and until completion of the Works, precast structures shall be adequately protected to preserve all permanently exposed surfaces and arises. The protection shall not mark or otherwise disfigure the concrete.

Transportation, storage and erection of the precast structures shall be done carefully and in such way as to avoid any damage and to keep the surfaces of the units free from dirt or other unwanted marks. Loading and unloading, storage and erection of the precast structures at the site shall be carried out by skilled labour and under supervision of a competent Engineer.

Any precast structures, which is found cracked, damaged or otherwise inferior in quality either before, or after erection shall be rejected and shall be replaced by the Contractor.

## Installation of Precast Concrete

All pre-cast concrete or mortar elements shall be well cleaned and thoroughly wetted with clean water before placing in their positions shown on the Drawings.

All precast structures shall be laid, bedded, jointed and fixed in accordance with the lines, levels and other details shown on the approved working Drawings.

Dry-pack mortar where necessary shall be used for jointing or packing as specified. The mortar shall be placed and packed in stages where possible from both sides of the space being filled using a hardwood stick hammered until the mortar is thoroughly compacted.

## Manufacturing in a Factory

Precast concrete units may be manufactured in a factory approved by the Engineer. The Contractor shall give the Engineer full information, in advance, concerning the name and address of the factory and details of the probable date of commencement of manufacture. The Contractor shall make the necessary arrangements for the Engineerto inspect the factory during working hours. The conditions shall also be valid for precast concrete.

## Work Programme and Method Statement

The Contractor shall submit to the Engineer for his approval, the Work Programme and Method Statement giving full details of his proposed method of carrying out all operations connected with the manufacture and erection of precast concrete units, which shall include the following:

* Period required to produce the Drawings and detailed calculation;
* Dates of commencement of manufacturing of the concrete units;
* Dates of delivery to site with the Technical Requirements for erection works;
* Sequence of erection and the period required for site erection works;
* A description of the types of casting bed, mould and shuttering for the various types of member;
* Procedure for reinforcing, concrete casting and method of curing the concrete;
* Procedure for transporting, handling, hoisting and placing of each type of precast concrete unit;
* The necessary strength of in situ cast concrete before starting site erection works;
* The design, manufacturing and mounting details to adapt the in situ cast concrete to the assembly; and
* Particulars of temporary support as deemed necessary to ensure adequate stability during erection and to sustain the effects of construction loads, wind loads or other transient loads.

No commencement of works shall be permitted until the programme and the method statement have been approved by the Engineer.

# Connection to Concrete Structures

All connections to concrete structures, temporary holes and opening in structures shall be made in accordance with the approved working Drawings and/or the directions of the Engineer.

All steel constructions and other items to be cast in, such as anchor bolts, steel frames, sockets, pipes, strips, waterstops of rubber or sheet metal, etc. shall be fixed and cast in by the Contractor in accordance with the approved working Drawings.

The Contractor shall also provide templates and other supplementary means for the correct positioning of the constructions and items as mentioned above.

The Contractor must ensure that all constructions and items as mentioned above are on site in time in order to avoid interruption during the execution of concrete works. If recesses are provided, these shall be sufficiently larger in size than the dimensions of the construction or items to be cast in.

## Building-In Pipes and Other Items

Pipes and other items passing through concrete shall wherever practicable be built into the structure as work proceeds, having been installed and connected to the remainder of the system to ensure proper fit prior to the start of any concreting.

Before placing concrete, all bolts, pipes or any other fixtures, which are to be built in shall be fixed in their correct positions. Cores and other devices for forming the holes shall be fastened to the formwork or shall be fixed otherwise. Holes shall not be cut in any concrete without prior written approval of the Engineer.

When that procedure cannot be adopted, holes or openings of suitable dimension shall be formed for such items to allow them to be built in later along with or after installation of the remainder of the system. Such holes or openings shall be of size and shape sufficient to permit proper placing and compaction of concrete or grout. The surfaces of the holes or openings shall be treated as construction joints.

All items to be built-in shall be securely supported in their correct position to prevent movement or damage during building in. In particular, any pipe with flanged joints shall not be concreted in until its accurate fit with other pipework has been checked and it has been secured in position.

Concrete used for building-in shall be of same class as the surrounding concrete, except that the mix shall also incorporate an approved expanding additive used with due regard to the manufacturer's instructions.

Cement sand mortar or cement grout used for this purpose shall also incorporate an expanding additive. Concrete, mortar and grout shall be placed and compacted by the methods, which will avoid moving or damaging built-in items.

Tapes swellable under water may be used for casting of pipes into concrete structures. Swellable tapes shall be applied according to the manufactures instruction and shall be approved by the Engineer. Movements within the joint shall be absorbed by the tape without affecting the sealing effect.

## Cutting or Displacement of Reinforcement

Reinforcement shall not be cut bent or displaced to facilitate building in without the Engineer's approval.

Where reinforcement is cut or displaced to facilitate the formation of holes or openings, the Contractor shall provide and fix additional reinforcement steel as required and approved by the Engineer to transfer the stresses from one side of the hole, opening or recess to the other.

Cutting or displacement of reinforcement shall only be permitted after the approval and inspection by the Engineer.

## Cleaning

Before filling or grouting, the holes and openings shall be roughed and cleaned to remove dust or other impurities. The openings shall be moistened with clean water before filling or grouting. The threads of anchor bolts and other items shall be cleaned and greased immediately after filling or grouting.

## Grouting in Narrow Spaces

In the event of the space between the fixture or unit to be cast in and the adjacent concrete being less than or equal to 25 mm, the grouting shall compose of one part cement and two parts of sand with an approved expanding additive.

## Joint between Old and New Concrete

Where new concrete is joined with old or existing concrete, the Contractor shall cut the old concrete to form a straight surface. The joint shall be considered as a construction joint and treated with an approved epoxy resin compound, prior to placing the new concrete. The exposed surface of the joint between old and new concrete shall be formed with a timber insert 20 mm x 25 mm. After the concrete has fully hardened, the timber insert shall be removed and the space filled with an approved epoxy sealer.

## Grouting under Handrails

The grouting under handrails shall be executed with a synthetic resin mortar based on epoxy and to be approved by the Engineer.

# Coatings on Concrete Surfaces

In general no coating shall be applied to any inside face of concrete tanks, chambers, or manholes.

Coatings shall be applied to underground outside face of concrete tanks, chambers, or manholes or concrete basements walls of buildings ~~s~~ in case ground or groundwater are aggressive to concrete in order to protect the concrete from the aggressive effects of saline groundwater or other unwanted matters.

The Contractor shall supply, deliver and apply all paints and protective coatings necessary. The type of coating to be used shall be bituminous, to the approval of the Engineer.

All priming-coats and undercoats shall be obtained from the same manufacturer. They shall be the type of primer and undercoat, which is recommended by the manufacturer for that particular paint or bitumen.

All paints and bituminous coatings shall be applied strictly according to the instructions of the manufacturer. All the paints shall be delivered to the site(s) in sealed containers with the manufacturer's name clearly shown. All coatings shall be applied by skilled labour under supervision of a competent foreman and to the satisfaction of the Engineer. No coatings shall be applied until the concrete has been cured, (for water or sludge retaining structures) the water tightness test has been passed and the prior approval of the Engineer has been obtained.

## Preparation of Surface

Before the application of any coating or primer, the surface of the concrete shall be thoroughly cleaned of all dirt, curing compound, dust and loose material and, where necessary, the surface shall be made good so that it is smooth and free from air or water holes. The surfaces of the concrete shall be dry before application of the first priming coat. The Contractor shall ensure that the required quantity of paints and coatings are on site prior to commencing work so as to avoid interruptions during the execution of the work.

## Application

No paint, bituminous coating or primer shall be applied until the surface to be treated has been approved by the Engineer. After the application of a particular coat, the surface shall be approved by the Engineer before the next coat is applied.

All paint, bituminous coating or primer shall be applied in quantity and workmanship in strict accordance to the instructions of the manufacturer. Only skilled workers are allowed to carry out coating works.

* Priming Coat:

The priming coat shall be applied in one direction and allowed to dry.

* Second and Subsequent Coats:

A heavy brush coat shall be applied at right angle to the previous coat and allowed to dry.

* Number of coats:

A minimum of two coats of bitumen excluding the priming coat shall be applied to concrete and other surfaces unless otherwise ordered by the Engineer.

* Holidays or Skips:

The applying of any layer or coating shall be done in such a manner that no holidays or skips shall occur on any treated surface.

* Quantity and Curing:

Each coat shall be thoroughly dry before applying a subsequent coat and shall be considered as dry when no staining occurs on a wet finger, which is rubbed vigorously over the coating. No coating shall be immersed in water for at least 7 days after it has been applied on the surface.

## Coating Underside of Structures

The underside of concrete structures in water logged ground shall be protected by the application of bituminous coating on top of a layer of cement sand mortar of minimum thickness 25 mm.

The cement sand mortar shall be constructed on top of the blinding concrete and when it has been properly cured and hardened, the bituminous coating shall be applied as described above prior to laying the structural concrete.

## 

# Pipelines

## Standards

ATV A 127 Rules for the static calculation of sewers [DWA/ATV-DVGW German Association for Water, Wastewater and Waste].

prEN 805 Requirements for water supply outside of buildings

EN 1610 Technical rules for construction of sewers

## Static Calculations for Pipelines

The static calculation of the pipes shall follow the detailed calculation procedure presented in ATV A 127. ~~”~~ The calculation procedure and basis are briefly outlined below:

1. Establishment of pipe data

This comprises pipe dimensions, pipe test load, unit weight and modulus of elasticity of pipe material. Safety class shall be according to ATV A 127.

2. Determination of soil conditions and geotechnical parameters

The contractor shall make his supplementary soil investigation in the pipe route in order to:

* classify the existing soil according to DIN 18196 and ATV A 127
* determine the in situ density in terms of percentage of the maximum dry density
* monitor the ground water level

Based on these results the contractor shall estimate the geotechnical parameters for the existing soil needed for his pipe calculations. The relevant geological parameters for pipe bedding, surrounding and backfilling shall be established also by the Contractor.

The pipe calculation shall be based on the following assumptions unless otherwise agreed with the Engineer:

* pipe bedding types are to be chosen from the approved Drawings
* pipe surrounding material above bedding shall be frictional soil as group G1 or G2 in ATV A 127
* backfill shall be selected excavated material suitable for the required compaction
* pipe surrounding and backfill shall compacted to the same density as the surrounding undisturbed soil or at least to 100% of the maximum dry Proctor density as defied in ATV A 127

3. Establishment of pipe trench data: This comprises earth cover, trench width at the top of the pipe excavation profile, bracing and working method.

4. Calculation of the pipe loading: Loading on the pipe due to earth, traffic, ground water, pipe dead load and load of water in filled pipe.

5. Calculation of stresses: Perpendicular force, bending moment and stresses in top, bottom and sides of the pipe are to be calculated.

6. Verification of safety: It shall be verified that the permissible stresses by applying safety factors according to safety Class A are not exceeded.

The contractor shall make the calculation for each pipe material, pipe diameter for all occurring pipe depth intervals (interval range shall not exceed 0.5 m) and for the different soil conditions and for other different conditions, which may vary due to working methods etc.

The calculation shall be systematised and presented in a form, which can be approved by the Engineer.

* strength on transverse loading;

criteria on cracks:

* resistance against forces arising from fabrication, transportation, storage and application of the concrete pipes and
* soil conditions and location of the pipes.

The followings details shall be indicated for each diameter of pipe to be used in the Works.

* the spigot and socket:
* circumference of the sealing ring in non-stretched position:
* thickness and shape of the sealing ring;
* the allowable angular deviation; and
* the type of bedding required for the different loading and soil conditions.
* the type of pipe surround required for the different loading and soil conditions.

The calculations must be approved by the Engineer before production or ordering of pipes shall be executed. The contractor is fully responsible for his calculations.

## Pipe Laying in Trenches

The contractor must ensure and document that the conditions and assumptions used in the structural calculations comply with the actual conditions of soil, excavations method, cross section of the trench, compaction, materials, earth cover etc.

Pipe lowering shall be carried out in a safe manner in accordance with applicable safety regulations and normal practices.

Bitumen coated pipes shall be handled with suitable slings which do not damage neither pipe nor coating. A sufficient number of lifting machines (e.g. side booms) shall be used to ensure that the pipe is not subject to detrimental stresses.

The Contractor shall, before lowering the pipe, ensure that the bottom of the trench is even and free from stones and other deleterious matter which may damage the coating.

The lowering-in procedure shall ensure that the pipe is not subjected to shocks or unnecessary stresses.

If a section is damaged during lowering, it shall be taken up again, repaired and relowered. Any damage which may affect the structural quality of the pipeline shall be treated as directed by the Engineer. The Contractor shall bear all costs associated herewith.

Where possible the ends of all lowered pipeline sections shall be closed with watertight caps. The Contractor is responsible for keeping the pipeline internally clean and free from foreign matter.

Any additional excavation required after the pipe has been lowered shall only be carried out with the permission and in the presence of the Engineer.

Each pipe immediately before being laid shall be carefully cleaned and examined for soundness. Any pipe which is damaged or has any perceptible objections will be rejected by the Engineer and replaced at the Contractor’s expense.

The formation of excavation for pipelines shall be even and free from stones and other protrusions. Pipes shall be laid in a dry excavation. If the formation of the excavation lies below the water table, the Contractor shall install a dewatering system, to the approval of the Engineer. Dewatering shall continue until all works below the water table are completed or as otherwise directed by the Engineer.

Each pipe shall be laid accurately to line and gradient so that the finished pipeline shall be in a straight line both in horizontal and vertical planes. The Contractor shall use suitable mechanical equipment, preferably hand operated, for pushing the pipes at the joints.

Where pipelines are to be constructed in trenches the Contractor shall provide, fix and maintain at intervals not exceeding 10 m, or at such points as may be directed by the Engineer, properly painted sight rails and boning rods of predetermined measurement for the boning in of individual pipes to correct alignment. The bobbing rod shall have a horizontal shoe to rest on the invert. The sight rails shall be situated vertically above the line of pipes or immediately adjacent thereto and there shall at no time be less than three sight rails in position on each length of pipeline under construction to any gradient. Consideration will be given by the Engineer to alternative methods for controlling alignment such as laser beam instruments.

The Contractor shall keep the interior of pipes clean and free from water, dirt, stones and other foreign matter as installation proceeds, and at the end of the day’s work or at other times when installation work is not proceeding the open ends of the pipes shall be sealed off by a suitable stopper. The Contractor shall take such precautions as are necessary to prevent pipes from floating.

The pipes shall be positioned and bedded in the trenches on the compacted bedding layer and jointed in an approved manner. The jointing of all pipes shall be carried out in strict accordance with the manufacturer’s instructions. All joint holes have to remain uncovered until passing the prescribed pressure test to the Engineer’s satisfaction. Concrete blinding layers shall be made of concrete C12/15 and shall be applied over the full width of the bottom of the trench in a minimum layer thickness of 10 cm. Any concrete bed shall be allowed to set and be thoroughly washed down before pipe laying commences.

### Trench-less Pipe Laying Methods

1. Excavation for entry, recovery pits, slurry sump pits, or any other excavation shall be carried out as specified in these Technical Requirements. Sump areas are required to contain drilling fluids.
2. After completing installation of the product the work site shall be restored. The work site shall be cleaned of all excess slurry left on the ground. Removal and final disposition of excess slurry or spoils as the product is introduced, shall be the responsibility of the boring contractor.
3. Excavated areas shall be restored. The cost of restoring damaged pavement, curb, sidewalk, driveways, lawns, storm drains, landscape, and other facilities is borne by the Contractor.
4. Methods to be used for marking utilities shall minimise impact on other construction or maintenance activities, including mowing operations, which may be conducted throughout the project on a cyclic basis. In order to accomplish this, marking by painting is preferred but not required. When and where flagging of existing utilities is required, these facilities shall not be flagged through an area for a length ahead of what construction can be accomplished in 14 consecutive days unless approved by the Engineer.

### Quality Control

1. A representative of the Contractor must be in control of the operation at all times. The representative must have a thorough knowledge of the equipment and the procedures to be performed, and is present at the job site during the installation.
2. The Engineer must be notified 48 hours in advance of starting work. The installation shall not begin until the Engineer is present at the job site and agrees that proper preparations have been made.

### Boring Path Report

The Contractor shall furnish a Bore Path Report to the Engineer within 14 days of the completion of each bore path. The completed As-Built-Design shall be submitted to the Engineer within 30 calendar days. The report shall contain:

1. Location of project.
2. Name of person collecting data, including title, position, and company name.
3. Investigation site location (contract plans station number or reference to a permanent structure within the project right of way).
4. Identification of the detection method used.
5. As-built placement drawings showing roadway plan and profile, cross section, boring location and subsurface conditions as defined in Bore Path Drawings below. Plan elevations shown shall be referenced to the given bench mark and to the used grid system and datum. These drawings shall be done to the same scale in black ink on white paper, of the same size and weight and as the contract Drawings.

### Boring Path Drawings

Boring Path Drawings shall be dimensionally correct copies of the contract plans. Notes shall be included on each drawing stating the final bore path diameter, facility diameter, drilling fluid composition, composition of any other materials used to fill the annular void between the bore path and the pipe. The drawings shall be produced as follows:

1. The contract plan view shall show the centre-line location of each pipe installed to an accuracy within 3 cm at the ends and other points physically observed. They show the remainder of the horizontal alignment of the centre line of each pipe and note the accuracy with which the installation was monitored.
2. As directed by the Engineer, either a profile drawing for each bore path, or a cross section of the roadway at a station specified by the Engineer, or a roadway centreline profile, shall be provided. They shall show the ground or pavement surface and the crown elevation of each facility installed, or installed and placed out of service, to an accuracy within 3 cm at the ends and other points physically observed. It shall show the remainder of the vertical alignment of the crown of each pipe and notes the accuracy with which the installation was monitored. On profile drawings for bore paths crossing the roadway the contract plans stationing of the crossing shall be shown.
3. On the profile drawings for bore paths paralleling the roadway the contract plans stationing are also shown.
4. If the profile drawing for the bore path is not made on a copy of one of the contract profile or cross section sheets, a 10 to 1 vertical exaggeration shall be used.

## Directional Boring

The work specified in this Section documents the approved construction methods, procedures, and materials for Directional Boring, also commonly called Horizontal Directional Drilling HDD.

### Drilling Fluids & Reamer Hole Diameter

The Contractor shall identify the source of fresh water for mixing the drilling mud. Approvals and permits are required for such sources as streams, rivers, ponds, or fire hydrants. Any water source other than potable water may require a pH test.

A mixture of bentonite clay or other approved slurry and potable water shall be used as the cutting and soil stabilisation fluid. The viscosity shall be varied to best fit the soil conditions encountered. Water shall be clean and fresh, with a minimum pH of 6.

No other chemicals or polymer surfactant is to be used in the drilling fluid without the written consent of the Engineer and after a determination is made that the chemicals to be added are not harmful or corrosive to the facility and are environmentally safe.

Monitoring of the drilling fluids such as the pumping rate, pressures, viscosity, and density is required during the pilot bore, back reaming, and pipe installation stages, to ensure adequate removal of soil cuttings and the stability of the borehole. Relief holes can be used as necessary to relieve excess pressure down hole. To minimise heaving during pullback, the pull back rate is determined in order to maximise the removal of soil cuttings without building excess down hole pressure. Excess drilling fluids shall be contained at entry and exit points until they are recycled or removed from the site. Entry and exit pits shall be of sufficient size to contain the expected return of drilling fluids and soil cuttings.

The Contractor shall ensure that all drilling fluids are disposed of or recycled in a manner acceptable to the appropriate local, state, or federal regulatory agencies. When drilling in suspected contaminated ground, the drilling fluid shall be tested for contamination and disposed of appropriately.

Any excess material shall be removed upon completion of the bore.

Restoration for damage to any transportation facility or non-transportation facility caused by heaving, settlement, escaping drilling fluid (fracout) or the directional drilling operation, is the responsibility of the Contractor. Any pavement heaving or settlement damage requires restoration/replacement of the pavement.

### Testing

When there is any indication a pipe has sustained damage and may leak, the work is to be stopped and the damage investigated. The Engineer may require a pressure test. The testing may consist of one of the following methods but shall always meet or exceed the testing requirements stated in these Technical Requirements:

1. Manufacturer's pressure testing recommendations for the type of pipe being installed are followed. The Engineer shall be notified and at his option be present during the test for review of the test results for compliance. The pressure test shall be performed within 24 hours. A copy of the test results shall be furnished to the Engineer. If the pipe is not in compliance with specifications, the Engineer may require it to be filled with flowable fill.
2. Product carrier pipes installed without a casing must meet pressure requirements set by the Manufacturer. If the Manufacturer does not require pressure testing, the Engineer may require at least one test. A copy of the test results shall be furnished to the Engineer. If the pipe is not in compliance with specifications the Engineer may require it to be filled with flowable fill.
3. The Engineer requires that conduit or pipe must meet or exceed soil tight joint requirements when leakage would not cause failure or adversely affect the integrity of the roadway pavement or shoulders.

Where leakage could adversely affect pavement or shoulder integrity, a water tight joint is required.

### Locating and Tracking

The Contractor shall describe the method of locating and tracking the drill head during the pilot bore. The Engineerrecognises walkover, wire line, and wire line with surface grid verification (i.e. True-Trac), or any other system as approved by the Engineer, as the accepted methods of tracking directional bores. The locating and tracking system shall be capable of ensuring that the proposed installation is installed as intended. If an area of radio signal interference is expected to exceed 1.5 m, the Engineer may specify the use of a suitable tracking system.

The locating and tracking system shall provide information on:

* Clock and pitch information.
* Depth.
* Transmitter temperature.
* Battery status.
* Position (x, y).
* Azimuth, where direct overhead readings (walkover) are not possible (i.e. subaqueous or limited access
* transportation facility.
* Before commencement of a directional drilling operation, proper calibration of the equipment (if required) shall be undertaken.

Alignment readings or plot points shall be taken and recorded every 1.5 m.

All facilities shall be installed in such a way that their location can be readily determined by electronic designation after installation. For non-conductive installations this shall be accomplished by attachment of a continuous conductive material either externally, internally, or integrally with the product. Either a copper wire line or a coated conductive tape for this material may be used. Any break in the conductor must be connected by electrical clamp of brass or solder and coated with a rubber or plastic insulator to maintain the integrity of the connection from corrosion.

### Equipment Requirements

The Contractor shall ensure that appropriate equipment is provided to facilitate the installation. Equipment shall be matched to the size of pipe being installed. Installations must be approved by the Engineer. The Contractor ensures that the drill rod can meet the bend radius required for the proposed installation.

Multiple pipe or conduit installations shall not exceed the total outside pipe diameters stated above.

### Obstructions

If during installation an obstruction is encountered which prevents installation of the pipe in accordance with this specification, the pipe may be taken out of service and left in place at the discretion of the Engineer, and shall immediately be filled with flowable fill. A new installation procedure and revised plans must be submitted to and approved by the Engineer before work can resume. If a bore path is abandoned without installing a pipe, the drawings shall show the abandoned bore path along with the final bore path. The abandoned bore path shall be noted as “Abandoned Bore Path.” They shall also show the location and length of the drill head and any drill stems not removed from the bore path. If conditions warrant removal of the materials installed in the abandoned bore path, as determined by the Engineer, during construction or in the future, the cost and responsibility shall be borne by the Contractor.

The type of material, horizontal and vertical location, top elevation and lowest elevation observed, diameter and material type of all utilities encountered and physically observed during the subsoil investigation shall be noted on the drawings.

## Building Pipes through Structures

Where pipes pass through a concrete wall or structure they shall be protected with a surround of concrete monolithic with the external face(s) of the structure. For pipes with nominal diameter of less than 600 mm unless otherwise shown on the approved drawings the concrete surround shall extend 300 mm from the wall or structure and shall have a thickness of 300 mm. For pipes with nominal diameter of 600 mm or more unless otherwise shown on the approved drawings the concrete surround shall extend 500 mm.

On spigot and socket jointed pipelines, except where otherwise specified hereafter, the length of the pipe passing through a wall shall be such that the concrete surround extends to the limit of the pipe socket.

The first pipe that is clear of concrete surround beyond the external face of a concrete wall or structure shall be a short length of either spigot and socked or double spigot to suit the flow direction and pipe material. The effective length of this pipe shall be 1.5 times the nominal bore or 600 mm, whichever is the greater.

Any over-excavation adjacent to a structure and beneath the formation level of a pipe trench to be excavated to make a connection to a plugged or capped pipe laid by the Contractor shall be backfilled to the formation level of the trench with concrete C12/15. This concrete shall be extended to the limit of the over-excavation along the line of the pipe trench and across the full width of the pipe trench or to the limit of the excavation whichever is the lesser.

The building-in of pipes in concrete walls and concrete slabs shall be deemed to be included in the unit price for concrete works. The building-in of pipes in manhole walls shall be deemed to be included in the unit price for manholes.

## Connecting to Existing Pipes

Where the drawings indicate that a connection of any kind to be made into an existing pipeline, or whenever directed by the Engineer to make such a connection, the Contractor shall investigate and verify all such connections at the start of the works. When necessary the Contractor shall excavate trial holes, to ensure that the materials to be furnished under the Contact will be suitable for making the connections.

The Contractor shall note that the period of interruptions of the existing service pipeline shall be kept to the minimum and shall arrange to make such connections at periods agreed with the Engineer.

The new pipe and connection together with any adjacent portion of the existing pipeline, which may have been disturbed by the Contractor, shall then be tested for leakage. Any existing pipe failing to pass the test due to damage occurring during the connection operation shall be removed and replaced by the Contractor. The test shall be repeated until a satisfactory test obtained. Any additional cleaning and disinfection procedures required in respect of the connection shall be performed by the Contractor at no additional cost.

## Thrust Blocks

The forces exerted by the following fluid or under pressure testing can be quite large. To compensate these thrusts, thrust blocks and anchorage must be made at the points where these thrusts are produced, that is:

* changes in direction (bends) or nominal diameter (reducers);
* branching (tees);
* pipeline ends (blank flanges) whether permanent or temporary as during testing of pipeline sections.

In large radius curves obtained by deviations at the pipe joints the thrusts are absorbed by the backfill.

At all the above points the Contractor shall construct a thrust block. Thrusts blocks shall be of reinforced concrete class C20/25 or mass concrete C12/15 to the dimensions appropriate for the purpose of the pipe, or as ordered by the Engineer. Thrust blocks shall extended from the fitting to solid undisturbed earth, shall be suitably reinforced, if necessary, and shall be installed so that all joints are accessible for repair. The concrete backfill to the excavation shall be placed the same day as any additional excavation for the thrust block or anchorage is carried out. No pressure shall be applied to thrust blocks until the concrete has matured as specified in the Sub-clause 6.7.15Loading of Concrete Structures.

Thrust forces and siting of the thrust blocks shall conform to the field test pressure and shall be calculated by the contractor considering the prevailing soil bearing capacity. [new]

## Securing against Uplift

Pipelines shall be secured against uplift by hydraulic pressure. [new] All static calculations shall be made for the empty pipe. [new]

Securing against uplift may be accomplished by backfilling with material or concrete or by anchorage.

The contractor has to submit his calculations for securing against uplift to the Engineer for approval.

## Concrete Protection to Pipelines

Concrete protection to the pipelines shall be either bed or surround and shall be of concrete C20/25 along such lengths as are shown on the approved drawings or ordered by the Engineer in writing.

After the pipeline has been tested by the Contractor and approved by the Engineer the pipe outer face shall be thoroughly cleaned. Concrete C20/25 shall be carefully placed and compacted thereon to avoid disturbing the pipes or joints until the appropriate profile for the type of protection required has been reached.

The concrete protection shall be placed to the full width of the trench and never less than 150 mm wider on each side than the barrel of the pipe. When support of excavation is provided building paper shall be placed against that support before concreting to facilitate withdrawal of the support.

In the case of spigot and socket pipes with flexible joints the concrete protection at each joint shall be interrupted in a vertical plane at the edge of the socket by a strip of fibreboard or other material approved by the Engineer and of the following thickness:

|  |  |
| --- | --- |
| Pipe Nominal ~~Bore~~ Diameter  [mm] | Fibreboard Thickness  [mm] |
| 300 or less  301 to 600  601 to 1100 | 12  24  36 |

Where two or more pipelines are laid in the same trench, the joints shall coincide at the points where the continuity of the concrete surround is broken at the joints in the pipeline with the longest pipes, and any intermediate joints in the other pipeline with shorter pipes shall be surrounded in concrete.

Pipework systems shall be complete and checked for correct position and alignment before and after being embedded in concrete.]

## Flange Connections

### Standards

Wherever pipes and fittings are connected by flanges, the following standards shall apply:

DIN 2527 Blind flanges, nominal pressures 6 to 100

DIN 2561 Oval screwed flanges, nominal pressures 10 and 16

DIN 2566 Screwed flanges, nominal pressures 10 and 16

DIN 2627-2638 Welding neck flanges

DIN 2641/42 Lapped flanges, plain collars

DIN 2652/53 Loose flanges and ring for welding

EN 1514 Flanges and their joints - Dimensions of gaskets for PN-designated flanges

### Fastenings

The dimensions of bolts, nuts, and washers shall be in accordance with the flange dimensions.

Bolts, nuts and washers and other demountable fastenings of all galvanised parts and also aluminium alloy parts shall be in stainless steel to the appropriate standard. P.T.F.E. washers shall be fitted beneath bolt-head and washer when fastening galvanised and aluminium alloy parts.

Fastenings, except high tensile, of all ferrous parts shall be steel prepared and galvanised to or sherardised to the relevant standards, primed and painted in accordance with location.

Unless specifically approved and required for superior protection, electro-galvanising, nickel, cadmium or any other plating process, except chromium plating, will not be acceptable, and shall not be offered.

## Pipe Thermal Insulation

All pipe work conveying cooling or heating fluids shall be insulated.

A vapour barrier jacket is required for chilled water piping, equipment, refrigerant suction piping, domestic cold water piping, air handling ducts and equipment with air temperatures of 15°C or less.

Fittings, valves, and flanges shall have an insulation thickness no less than the adjacent piping but must be removable without damage for easy reapplication.

Pipe insulation in maintenance areas (mechanical rooms, accessible shafts, etc.) is subject to mechanical damage (crushing, abrasion and laceration) resulting from maintenance activities. Rigid insulation materials protected with appropriate casings and vapour barrier linings are required in these spaces.

Insulation shall have a durable finish suitable for painting for colour coding, or other identification marking.

### Standards

ASTM C 533 Calcium Silicate Block and Pipe Thermal Insulation

ASTM C 534 Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form

ASTM C 547 Mineral Fibre Pipe Insulation

ASTM C 552 Cellular Glass Thermal Insulation

ASTM C 647 Properties and Tests of Mastics and Coating Finishes for Thermal Insulation

ASTM C 1136 Flexible, Low Permeance Vapour Retarders for Thermal Insulation

EN 12237 Ventilation for buildings - Ductwork - Strength and leakage of circular sheet metal ducts

### Insulating Material

Materials shall be compatible and shall not contribute to corrosion, soften, or otherwise attack surfaces to which applied in either the wet or dry state. Materials shall be asbestos free.

A complete list of materials, including manufacturer's descriptive technical literature, performance data, catalogue cuts, and installation instructions. The product number, k-value, thickness and furnished accessories for each pipe system requiring insulation shall be included.

After approval of materials and prior to applying insulation a booklet shall be prepared and submitted for approval. The booklet shall contain detail drawings showing the insulation material and insulating system for each pipe required to be insulated per this specification.

The insulation shall have a minimum thickness of 50 mm and a thermal conductivity coefficient of 0.02 W/(m x K) maximum at a mean temperature of 24°C.

## Jackets

Jackets used on insulation exposed in finished areas shall have white finish suitable for painting without sizing. Based on the application, insulation materials which require factory applied jackets are mineral fibre and cellular glass. Jackets shall be easily removable and reusable.

### Aluminium Jackets

Aluminium jackets shall be corrugated, embossed or smooth foil, 0.4 mm nominal thickness or with factory applied moisture retarder. Aluminium jacket securing bands shall be of stainless steel, 0.4 mm thick, 20 mm wide.

Aluminium jacket circumferential seam bands shall be 50 x 0.4 mm aluminium matching jacket material. Bands for insulation below ground shall be 20 x 0.5 mm thick stainless steel, or fibreglass reinforced tape. The jacket may, at the option of the Contractor, be provided with a factory fabricated longitudinal joints. The bands at the circumferential joints shall be designed by the manufacturer to seal the joints and hold the jacket in place.

### PVC Jackets

PVC jacket and fitting covers shall have high impact strength, UV resistant rating or treatment and moderate chemical resistance with minimum thickness 0.8 mm and shall otherwise comply with Sub-clause 1.16.36. (Plastic Pipes).

### PEHD Jackets

PEHD jacket and fitting covers shall have high impact strength and moderate chemical resistance with minimum thickness 0.6 mm and shall otherwise comply with Sub-clause 16.36.1PE-HD Pipes

## Galvanised Folded Spiral Pipe Jackets

Galvanised folded spiral pipe jackets shall have outside fold and only be used for uncovered laying inside or outside of buildings and shall comply to EN12237.

### Vapour Retarder Coating

To ensure integrity of the vapour barrier, joints shall be coated with a vapour sealing compound compatible with the aluminium foil vapour barrier. The vapour retarder coating shall be fire and water resistant and appropriately selected for either outdoor or indoor service. Colour shall be white.

### Installation General

Except as otherwise specified, material shall be installed in accordance with the manufacturer's written instructions. Insulation materials shall not be applied until tests specified in other sections of this specification are completed. Material such as rust, scale, dirt and moisture shall be removed from surfaces to receive insulation. Insulation shall be kept clean and dry. Insulation shall not be removed from its shipping containers until the day it is ready to use and shall be returned to like containers or equally protected from dirt and moisture at the end of each workday. Insulation that becomes dirty shall be thoroughly cleaned prior to use. If insulation becomes wet or if cleaning does not restore the surfaces to like new condition, the insulation will be rejected, and shall be immediately removed from the site. Joints shall be staggered on multi-layer insulation.

Installation shall be with full length units of insulation and using a single cut piece to complete a run. Cut pieces or scraps abutting each other shall not be used.

### Installation of Flexible Cellular Insulation

Flexible cellular insulation shall be installed with seams and joints sealed with a contact adhesive. Flexible cellular insulation shall not be used on surfaces greater than 93°C. Seams shall be staggered when applying multiple layers of insulation. Insulation exposed to weather and not shown to have jacketing shall be protected with two coats of UV resistant finish as recommended by the manufacturer after the adhesive is dry.

Flexible cellular pipe insulation shall be tubular form for pipe sizes 150 mm and less. On pipes larger than 150 mm, insulation shall be adhered directly to the pipe. Seams shall be staggered when applying multiple layers of insulation. Bends shall be insulated with mitre-cut pieces the same size as on adjacent piping. Screwed fittings shall be insulated with sleeved fitting covers fabricated from mitre-cut pieces and shall be overlapped and sealed to the adjacent pipe insulation.

Pre-cut or preformed insulation shall be placed around all fittings and accessories.

Upon completion of insulation installation on flanges, unions, valves, anchors, fittings and accessories, terminations, seams, joints and insulation not protected by factory vapour retarder jackets or PVC fitting covers shall be protected with two coats of vapour retarder coating with a minimum total thickness of 2 mm, applied with glass tape embedded between coats. Tape seams shall overlap 25 mm. The coating shall extend out onto the adjoining pipe insulation 50 mm. Fabricated insulation with a factory vapour retarder jacket shall be protected with two coats of vapour retarder coating with a minimum thickness of 2 mm and with a 50 mm wide glass tape embedded between coats. Where fitting insulation butts to pipe insulation, the joints shall be sealed with a vapour retarder coating and a 100 mm wide tape which matches the jacket of the pipe insulation.

Anchors attached directly to the pipe shall be insulated for a sufficient distance to prevent condensation but not less than 150 mm from the insulation surface.

### Factory Pre-insulated Pipe Systems

Factory pre-insulated pipe systems shall be used for buried pipes. The joints shall be gasketed push-joints. The carrier pipe shall be steel, copper or GRP. Insulation shall consist of a layer of polyurethane foam, with a PVC or PELD outer casing. The joints shall provide for expansion and contraction through the use of a pre-insulated grooved coupling with two EPDM sealing gaskets. The void between carrier pipe and casing at the pipe ends shall be sealed by an EPDM end seal ring. Fittings shall be insulated with one-piece, pre-moulded, high-impact PVC or PELD fitting covers with fibre glass inserts and accessories. Casing joints shall be covered by self adhesive PVC tape or with heat shrinking PELD sleeve.

### Pipe Heating Cables

The heating cable shall consist of 2 nickel-coated-copper bus wires embedded in a radiation-crosslinked polymer capable of regulating its power output in response to temperature changes all along its length with a self-regulating index of no less than 90% between 10°C and 60°C. The heating cable shall be covered with a radiation- crosslinked modified polyolefin dielectric jacket which in turn shall be covered with a tinned copper braid (10 Ω/1,000 m maximum electrical resistance) and an outer modified polyolefin jacket.

The heating cable shall be installed under the pipe's thermal insulation without spiralling and with sufficient heat output to maintain the pipe temperature of no less than 5°C. when outside ambient is -10°C and the average wind speed is 25 km/h. When used on non-conductive pipe, the heater shall be attached to the pipe with a solid aluminium tape. After cable installation and before and after installation of the pipe insulation, the heating cable shall be tested using a 2,500 V megger. Minimum electrical insulation resistance shall be 20 MΩ regardless of circuit length. Both bus wires and braid shall be tested to verify the connection of all splices and tees. A copy of the meggering report shall be supplied to the Engineer. All material shall be installed in accordance with the manufacturer's recommendations.

## Fittings, Valves and Accessories

The nominal working pressure of valves, fittings and accessories shall be 1.0 or 1.6 MPa. All valves, dismantling pieces, flexible couplings connections to pipes shall be flanged supplied with bolts, gaskets, etc.

Surface boxes, covers and other accessories shall be supplied for all valves and fittings for which manholes with access opening are not foreseen. Access openings shall be positioned directly above the valves, fittings or accessories to allow dismantling with lifting facilities.

### Tees and Wyes

Tees, crosses, couplings, Y-bends or other fittings that provide means of dividing or uniting flow in pipelines shall be factory made and shall comply with the respective standards. These fittings may be connected to pipes by welding. For connection of all kind of valves and return flow preventer, welding neck flanges shall be applied if the nominal diameter of the pipe is greater or equal 150 mm.

### Dismantling Joints

All valves, fittings and accessories etc. shall be easily accessible for disassembly and reassembly. Valves, fittings and accessories etc. shall be mounted with dismantling joints or adjustable and removable joints of an approved manufacture to permit the dismantling of the valve, fittings and accessories.

### Anchoring Sleeves

Anchoring sleeves~~, ,~~ shall be used whenever a ductile cast iron, steel or plastic pipe shall pass through a concrete wall of water or sludge retaining tanks.

Sleeves shall be of stainless steel No. 1.4301.

Sleeves shall be sealed on one or two sides with permanently elastic EPDM gasket elements. Seals between pipes and conduits shall be made of seal belts expanded when wrenched tightened to fill the gap and create the seal. The seal belt shall consist of EPDM reinforced with stainless steel bolts to be tightened with stainless steel nuts.

## Testing of Pipelines

Before pipe testing the trench must be filled on the pipe barrels, leaving the joints uncovered so as to prevent the pipeline from moving whilst leaving the joints accessible. Thrust blocks must also be constructed before testing. On roads with heavy traffic the backfilling at joints may take place before testing if the Engineer so allows in writing. At least 2 days notice must be given in writing to the Engineer before pressure testing of any section is commenced. [new]

Pipes shall be filled and tested in sections of convenient lengths, which must not exceed 500 m. Where pipes are laid with steep gradients the length of pipes tested at any one time shall be as directed by the Engineer.

The ends of pipes under test shall be closed by means of caps or blank flanges with anchors all provided by the Contractor. Valves must not be used for this purpose. All scour valves and air valves shall be replaced by blank flanges before the commencement of the tests.

After laying, jointing and anchoring the pipe shall be slowly and carefully charged with water so as to avoid water hammer and all air shall be released through the upper pipe end or in case of an intermediate high point by installing a service connection with a tap. Pipes internally lined with mortar shall be allowed to stand full for at least 24 hours before testing.

The test pressure shall be applied by means of a manually or motor operated test pump connected to the pipe and two parallel installed pressure gauges calibrated at an approved testing laboratory.

During the test the pipe joints shall be inspected for leakage.

Should leakage of water occur at the joints, the joint shall be reassembled to eliminate such leakage or, should this not prove possible, the Contractor shall supply and assemble new joints at his own expense. Should any pipe or joint burst or should water leak through the body of a pipe or joint the Contractor shall forthwith remove the faulty pipe or joint and replace them with new at his own expense. In all the above cases the length under test shall be re-tested as above described and the process repeated, if necessary, until the pipeline satisfactorily withstands the prescribed test.

A test report shall be prepared in respect of each and every test performed. The test report shall contain as a minimum the following data:

* Number and date of the test
* Description of the stretch tested with unambiguous indication of the extremities of the stretch
* Sketch showing in the order of laying, the number and the characteristics of the pipes, the fittings the specials and other apparatus incorporated in the stretch
* Duration of the test, test pressure, results obtained
* Decisions relative to possible repair works and conclusions

The test report shall be signed by the Contractor and the Engineer.

The Contractor shall provide labour, install and work the test pump, pressure gauges and all other equipment required for the test and he shall fill the pipes with water and subsequently empty them after the test, all to the approval of the Engineer. Water drained from the pipes shall be discharged in a way that does not affect the stability of the Works or adjacent structures.

The Contractor shall be deemed to have allowed for all expenses in connection with pipe testing.

~~.~~ The Contractor shall provide all labour, pumps, manometers and auxiliaries during the test periods; as soon as the Engineer may require. All tests shall be conducted in the presence of the Engineer.]

If any leak in joints or evidence of defective pipe is disclosed, the work shall be immediately detected and corrected or replaced to the Engineer’s satisfaction. No makeshift repairs or application of patching compounds shall be permitted. After the correction is made, supplementary tests shall be run until a satisfactory working condition is obtained.

With the approval of the Engineer pipelines with an internal diameter greater than 100 cm may alternatively be tested by a combination of visual inspection from the inside and the use of equipment designed to test the tightness of individual joints. This test, however, does not relive the Contractor of his obligation to guarantee watertightness of pipelines. Furthermore, individual joints have to be testable (i.e. double gasket with spacing and devices to connect test equipment).

### Testing of Gravity Pipelines

Gravity pipelines shall be tested with water or air in accordance with DIN EN 1610.

The test pressure is a minimum of 5 m head of water above the crown of pipe measured at the deepest invert level of the pipe to be tested but maximal 5 m. The test pressure time will be a minimum of 30 minutes. The losses shall be replaced steadily.

The pipe will be taken as watertight if the replaced water losses during 30 minutes are less than 0.2 l/m2 (wetted inner surface) and if the joints are watertight (see above) and if no other leakage is visible.

### Testing of Pressure Pipelines

Pressure pipelines (together with all specials and valves incorporated) shall be tested with water in accordance with prEN 805:

| Description | test pressure | test duration | test criteria |
| --- | --- | --- | --- |
| Ductile cast iron pipelines | NP 10: 1.5 MPa  NP 16: 2.1 MPa | ND ≤200: 3 hours  200 < ND ≤400: 6 hours  ND >400: 12 hours | max pressure drop for  NP 10: 10 kPa  NP 16: 15 kPa |
| Steel pipelines | NP 10: 1.5 MPa  NP 16: 2.1 MPa | ND ≤200: 3 hours  200 < ND ≤400: 6 hours  400 < ND ≤700: 12 hours  ND >700: 24 hours | max pressure drop for  NP 10: 10 kPa  NP 16: 15 kPa |
| Reinforced concrete pipes | 1.4 x NP  (NP <0.25 MPa)  NP +0.1 MPa  (NP >0.25 MPa) | ND ≤700: 12 hours  ND >700: 18 hours | average replaced water losses during the first 6 hours less than 0.15 l/m2/hour (wetted inner surface) |
| Prestressed concrete pipes | 1.5 x NP  (NP ≤1 MPa)  NP +0.5 MPa  (NP >1 MPa) | average replaced water losses during the first 6 hours less than 0.02 l/m2/hour (wetted inner surface) |
| PVC, PE-HD | Test according to EN 805 | | |
| GRP | Test methods of EN 805 shall be applied | | |

## Inspection of Pipelines

The contractor shall furnish and maintain in good condition, all equipment necessary for the proper execution and inspection of the work.

### Pipe Pigging

Pipes from thermoplastic or any other flexible material with a nominal diameter ~~bore~~ in excess of 150 mm shall be tested for ring deflection by pulling a mandrel through the pipe. This test shall be performed 3 months after backfill is completed. Mandrel shall be a minimum of one pipe diameter long and mandrel diameter shall be sized in accordance with pipe manufacturer’s requirements for maximum ring deflection.

If mandrel cannot pass through pipe it will be assumed that ring deflection has been exceeded. In this case pipe shall be uncovered, removed and replaced. Special attention should be directed to pipe bedding.

Where pipes are found to have deflected in excess of the approved limit the pipes shall be uncovered, removed and replaced.

The Contractor shall provide for the Engineer’s use copies of all data relating to pipe deflections.

### Pipe TV-Inspection

Trunk (pressure) mains with nominal diameter in excess of 200 mm but smaller or equal 800 mm shall be inspected by close circuit television (CCTV). The inspection shall be conducted in the presence of the Engineer. TV inspection shall be recorded in colour on a VHS tape. Log sheets indicating date of inspection, location of services, any manholes, direction of view, pipeline length, and all found defects shall be kept during inspection. Tapes shall be numbered and marked with the location of the inspection.

The camera shall be equipped with a remote reading footage counter and shall be checked and calibrated, if required, before inspection begins. Camera runs should start from the upstream end of the pipe being inspected and shall be pulled through at a speed that allows a close of inspection and shall not exceed 6 m per minute. The Camera shall be in focus and display a clear view of the pipe on the field monitor.

Prior to camera inspection water shall be flushed through the pipe being inspected to make low points easier to detect. Additionally, during camera inspection the Engineer may require flowing water through the pipe.

Should the results of this inspection reveal any defects, the contractor will be required to repair or replace these defects as ordered by the Engineerat the sole cost of the contractor.

## Cleansing and Disinfection of the Pipelines

The cleaning and disinfection of water supply pipes shall take place in four stages complying with DVGW W 291, disinfection of water pipelines.

### Preliminary Flushing

All pipes from 100 to and including 600 mm diameter shall be preliminarily flushed at least once at high rates of flow (velocity shall exceed 1.5 m/s). The Contractor shall prepare a flushing plan and submit it to the Engineer for approval.

### Cleansing

All pipes for water supply shall be cleaned with clean water for at least 5 minutes at a rate of flow sufficient to obtain a velocity exceeding 1 m/s. This cleansing procedure shall be repeated until any trace of taste or smell has disappeared from the water.

### Disinfecting of Water Supply Pipes

Following the satisfactory cleansing for water supply lines the Contractor shall with the use of a portable dosing system or by some other approved method introduce a solution of a sterilising chemical containing chlorine into the pipeline. The solution shall be introduced at a very slow rate and shall be of such strength as to give a chlorine concentration of not less than 50 parts per million (ppm) throughout the length of the pipelines.

All valves~~)~~ on the distribution system shall be opened successively, working progressively away from the place where the solution is introduced. Each valve shall be closed when the water discharged begins to smell of chlorine. The whole system shall then remain charged for 24 hours, after which the water shall show residual chlorine contents of not less than 10 ppm.

If no residual chlorine is found or if the residual chlorine is less than 10 ppm, the sterilisation process shall be repeated until a satisfactory result is obtained.

### Bacteriological Testing of Water Supply Pipes

After the disinfection period of 24 hours the water shall be evacuated from the water supply pipes and the pipe system shall then be refilled with potable water having a concentration of residual chlorine of about 0.1 ppm.

A number of water samples to be determined by the Engineer shall then be taken and subjected to laboratory tests for coliform bacteria. If the tests show presence of coliform bacteria, the whole cleaning and disinfection process from preliminary flushing shall be redone until the result is negative.

The above described cleaning and disinfection procedure shall apply only to water supply pipes. Pipes for pumped sewage shall just be flushed and cleansed obtaining the above described flow rates.

The Contractor shall include all costs of labour, transport, materials, equipment, chemicals and water necessary for the satisfactory completion of the cleansing and sterilisation operations in his prices.

## Concrete Pipes, Pipe-Laying and Testing

### Standards

The Contractor shall carry out the works described in accordance with the appropriate standards or equivalent local or international standards. The main standards are, but shall not be limited by the following:

AWWA C 301 Prestressed Concrete Pressure Pipe, Steel Cylinder Type, for Water and Other Liquids.

AWWA C 304 Design of Prestressed Concrete Cylinder Pipe

EN 1916 Concrete pipes and fittings, unreinforced, steel fiber and reinforced

DIN 4034 Prefabricated concrete manholes, unreinforced, steel fiber and reinforced

DIN 19850-3 Fibre-cement manholes for use in sewerage systems; dimensions and technical delivery conditions

EN 639 Common requirements for concrete pressure pipes including joints and fittings

EN 640 Reinforced concrete pressure pipes and distributed reinforcement concrete pressure pipes (non-cylinder type), including joints and fittings

EN 641 Reinforced concrete pressure pipes, cylinder type, including joints and fittings

EN 642 Prestressed concrete pressure pipes, cylinder and non-cylinder, including joints, fittings and specific requirements for prestressing steel for pipes

Concrete pipes shall be used exclusively for buried gravity pipes within the fields of sewerage, rainwater drainage and waste water treatment works, but always above the groundwater level.

The type of concrete used in the manufacture of the pipes shall be in accordance with these Technical Requirements. ~~.~~ No admixtures shall be added to the concrete without the written approval of the Engineer. Steel reinforcement for concrete pipes shall be in accordance with these Technical Requirements.

### Classification

Concrete pipes used in the Works shall be classified under the following categories.

* 1. Pipes with internal diameter ≤300 mm and below may be without reinforcement provided they meet the requirements of extra strength pipe class. They shall in accordance to EN 1916 (concrete pipes).
  2. Pipes with internal diameter >300 mm and above shall comply with EN 1916 (reinforced concrete pipes).
  3. Prestressed concrete pipes.

The pipes mentioned under (a) shall have the following principal features:

* a self centring socked joint with a performed gasket or rubber ring for insertion of the spigot.
* The pipes mentioned under (b) shall have the following principal features:
* a reinforcing cage (or cages) of steel bars, wire fabric or welded fabric.
* a wall of dense concrete covering the reinforcement cage or cages.
* a self-centring socked joint with a performed gasket or rubber ring for insertion of the spigot.

The pipes mentioned under (c) shall have the following principal features:

* Lined cylinder pipe (LCP): a concrete core cast inside a steel cylinder that serves as a watertight membrane. The cured concrete core is subsequently wire-wrapped and externally coated with a cement-rich mortar
* Embedded cylinder pipe (ECP): a steel cylinder fully encased in a concrete core which is subsequently wire-wrapped and externally coated with a cement-rich mortar.
* a self-centring socked joint with a performed gasket or rubber ring for insertion of the spigot.

### Quality and Testing of Materials

The quality of the concrete for the pipes shall conform to the requirements as specified in EN 1916.

Generally, no reinforcement shall be used in the making of the pipes until the materials have been tested as specified. Certified copies of the test certificates shall be submitted to the Engineer.

~~…~~

Concrete for concrete pipes shall be manufactured from sulphate resisting Portland cement (CEM I) class CE I 42.5 in accordance to EN 197. [new]

## Supply of Concrete Pipes

### Non-Reinforced Concrete Pipes

Dimensions of not reinforced concrete pipes (300 mm internal diameter and less) shall be dimensions conform to EN 1916 and shall otherwise conform to the requirements.

The plane of the pipe ends except for shapes shall be perpendicular to the longitudinal axis of the pipe. The interior surface shall be smooth and well finished. The pipes shall have the type of joints specified in Sub-clause 16.20 Joints .

The pipe shall be free from fractures, cracks, laminations, or surface roughness.

Each pipe shall be marked clearly and legibly to show the manufacturer’s name or trade mark, year and week number of production and minimum test bearing capacity (FN in kN/m).

### Reinforced Concrete Pipes

Dimensions of reinforced concrete pipes (internal diameter greater than 300 mm) shall conform to EN 1916 and shall otherwise conform to the requirements.

The circumferential steel reinforcement cage(s) shall be made of continuous or welded steel bars or wires of minimum cross sectional area of 1% of the cross sectional area of concrete per metre length of pipe wound in a helical form, and individual bars shaped and butt or lap welded into cages, as approved by the Engineer. The circumferential bars or wires in the cage(s) shall be accurately spaced and shall be rigidly held by means of longitudinal bars or wires securely fixed to them in an approved manner. The axial pith of the spiral reinforcement shall be less than 150 mm. Each cage shall be fabricated and rigidly held in such a manner that the reinforcement will remain in proper position during the casting of the pipe. The minimum cover to the reinforcing steel shall be 40 mm unless directed otherwise by the Engineer.

Concrete pipes shall be manufactured by either the centrifugal spun process or be vertically cast in a steel mould and shall be mechanically vibrated during the manufacturing.

### Prestressed Concrete Pipes

Dimensions of pre-stressed concrete pipes shall conform to EN 1916 and shall otherwise conform to the requirements.

Prestressed concrete pipes shall be of Lined cylinder pipe (LCP) or Embedded cylinder pipe (ECP) type

LCP pipe shall have a concrete core cast inside a steel cylinder that serves as a watertight membrane. The cured concrete core shall be wire-wrapped and externally coated with a cement-rich mortar.

ECP pipe shall have a steel cylinder fully encased in a concrete core that is subsequently wire-wrapped and externally coated with a cement-rich mortar.

The minimum cover to the steel cylinder inside shall be 40 mm, the minimum cover to the prestressing wires outside shall be 40 mm unless directed otherwise by the Engineer.

The spigot and bell joint rings shall be galvanised steel.

### Spigot and Bell Rings Outside Corrosion Protection

A grout band shall be strapped to the outside of the completed joint so that it encompasses the external joint recess. A grout consisting of one part Portland cement, three parts sand, and sufficient water shall be mixed to produce a grout free of lumps and with a consistency of heavy cream. The grout shall be poured into the opening at the top of the grout band so that it completely fills the external joint recess. The grout should be rodded or puddled to ensure complete filling of the joint recess. A stiffer mix can be used to trowel over the opening at the top of the grout band.

### Spigot And Bell Rings Inside Corrosion Protection

The interior, exposed surfaces of the steel joint rings shall be protected in one of the following ways:

* 1. The interior joint recess shall be grouted using a stiff 1:3 Portland cement/sand mortar.
  2. A butyl rubber mastic joint filler shall be applied to the spigot end or bell socket prior to joining the pipe such that the mastic squeezes out and fills the interior joint recess.

## Joints

### Types of Joints

Unless otherwise specified, the joints for concrete pipes shall be of the spigot and socket type. Joints shall be carried out in accordance with the requirements as described in the relevant standard (EN 1916) and instructions of the manufacturer in the case of factory made pipes.

At changes in direction (bends) or nominal diameter (reducers) and when branching (tees) is constructed or at pipeline ends (blank flanges) joints shall provide restraint if the pipe is not secured.

### Sealing of Joints

The joints between the pipes shall be sealed with sealing rings made of styrene butadiene rubber. The sealing rings shall be stored in well covered areas and different types and/or dimensions shall be kept separate. Lists of deliveries shall be supplied and shall be handed over to the Engineer. The material shall be applied according to the recommendations of the manufacturer and the pipe joints must be of such quality that a leak-proof connection is guaranteed.

Joint lubricants for sliding joints shall have no deleterious effects on either the joint rings or pipes and shall be unaffected by the liquid to be conveyed in the pipes.

## Manufacturer’s Tests

### Water-Tightness

Concrete (not reinforced) pipes and their joints, as well as reinforced and prestressed pipes shall be leak tested as specified in EN 1916.

Furthermore, pre-stressed concrete pipes shall also be tested for the density of the concrete (water penetration test) in accordance with the requirements as specified in DIN 1048 T1.

### Strength of the Pipe

Generally, concrete pipes and reinforced concrete pipes shall be tested for strength according to EN 1916.

### Transport and Storage

Transport and storage of concrete pipes shall generally be in accordance with these Technical Requirements and the directions as specified in DIN 19695.

### Rejection of Pipes

Inspection of the pipes as may be deemed necessary by the Engineerwill be made at the place of manufacturer. ~~.~~ Pipes will be rejected as unsuitable for the Works for any of the following reasons:

1. A piece of any size broken out of the pipe.
2. Defects that indicate imperfect mixing or moulding of the concrete.
3. Any crack extending through the wall of the pipe and having a longitudinal or transverse length greater than the wall thickness of the pipe.
4. Any shattering or flaking of concrete
5. Any concrete deficiency on the inner surface of the pipe deeper than 10 mm of any area or on the outer surface of the pipe deeper than 10 mm of an area greater than 100 cm2. A concrete deficiency.~~.~~

The deficiencies in wall thickness permitted herein do not apply to gasket contact surfaces in gasket jointed pipe. Dimensions and tolerances of such contact surfaces shall be submitted for approval.

1. A variation of more than 1 % from the true circle of the specified pipe internal diameter.
2. Rock pockets and water pockets in any pipe.
3. Exposure of any reinforcement or insufficient cover to reinforcement.
4. Surface defects indicating honey-comb or open texture.
5. Separation or ”blisters”.
6. Any continuous crack having surface width of 0.25 mm or more and extending for a length of 300 mm or more, regardless of depth or position in the wall of the pipe.
7. The pipe fails the strength test.

### Repair of Pipe Imperfections

For pipes that are not rejected according to the above causes the following repair methods for small imperfection shall be applied:

### Preparation of Surfaces to be repaired

Unsound or imperfect concrete shall be removed by careful chipping. Edges where concrete has been chipped out shall be scraped and square with the surface, leaving no feather edges. The chipped area shall be washed with water to remove all loose material and concrete dust.

Surfaces within the trimmed areas shall be kept wet for several hours, preferably overnight before the repair is made. All surfaces in areas to be repaired shall be damp, but not wet, when the material is applied.

### Placement of Repair Mortar

The mortar used for repair shall in generally comply with the specification and contain an expanding additive.

Workmanship of repair shall be according to Technical Requirements. [new]

## Laying of Concrete Pipes

### Excavation and Backfilling

Excavation and backfilling for pipelines shall be carried out in accordance with these Technical Requirements.

### Granular Material for Bedding to Pipelines

In trenches, except where concrete protection is required, pipes generally shall be laid on a well-compacted bed of granular material after excavation. Granular material for pipe bedding shall consist of gravel~~.~~

For pipes up to 1,200 mm internal diameter the material shall be graded 20 mm to 5 mm all passing 20 mm and not more than 20% passing 5 mm sieves.

For pipes above 1,200 mm internal diameters internal diameter the material shall be graded 37.5 mm to 5 mm all passing 37.5 mm not more than 45% passing 20 mm and not more than 20% passing 5 mm sieves.

### Laying of Pipes

Laying of pipes shall generally be in accordance with these Technical requirements, as specified in DIN EN 1610, and with the instruction of the manufacturer in the case of the factory made pipes, unless otherwise directed by the Engineer. During the jointing, displacement of the rubber ring shall be prevented in the case of adopting the sliding method. The noose shall not be removed until the joint is made and the pipes sufficiently supported and after the approval of the Engineer.

Except where concrete protection is to be provided the Contractor shall not, at any stage in the laying of pipes support the pipes on anything else than granular material. Temporary packing of brickwork, stones etc., will not be permitted.~~.~~

### Pipe Jointing

The Contractor shall ensure that all pipe joints are made strictly in accordance with the manufacturer’s recommendations.

Joint rings and gaskets shall be stored until needed in a cool place protected from direct sunlight.

Before making any joint the Contractor shall ensure that interior of each pipe or fitting is clean. The Contractor shall clean the end of each pipe to be jointed and shall prepare the ends for jointing as necessary. All mechanical joints shall have their coating made good before assembly.

The Contractor shall use only the proper jointing parts as specified and obtained from the suppliers of pipes or fittings. All joints shall be assembled and tightened in accordance with the Manufacturer’s instructions.

Special care shall be taken to see that the axis of the concrete pipe to be laid forms one straight line with the axis of the previously laid pipe. Spigot and socked ends shall be central with regard to each other.

The following measures shall be taken for joints made with the “sliding method”. The rubber ring and the edge as well as the internal slide of the socket shall be coated with a non-acid sliding substance. The Contractor has to provide that the substance to be used needs the approval of the manufacturer of the rubber rings. For joints executed by ”rolling” of the rubber ring the Contractor shall ensure that spigot and socked ends and the rubber ring are completely dry and clean before insertion of the joint. The positioning of the rubber ring shall be such that twisting is prevented while the circumferential stress is applied before each joint is made.

After completing the joint any protective or other coating shall be made good and any lining and joint protection completed as specified without delay.

## Ductile Iron and Steel Pipe Lining and Coating

### Standards

The Contractor shall carry out the works described in accordance with the appropriate standards or equivalent local or international standards. The main standards are, but shall not be limited by the following:

AWWA C 203 Coal tar enamel coating

AWWA C 213 Fusion bonded epoxy coating for the interior and exterior of steel water pipelines

BS 4164 Hot applied coating materials

DIN 2880 Cement mortar inside lining for ductile cast iron and steel pipes and fittings, application

DIN 30670 Polyethylene coating

DIN 30671 Coating of buried steel pipes with duroplastics

DIN 30672 Corrosion protection tape and shrinking sleeves

DIN 30673 Corrosion protection with bituminous wraps

DIN 30674-1 Corrosion protection of ductile iron pipes: PE-coating

DIN 30674-2 Corrosion protection of ductile iron pipes: cement-coating

DIN 30674-3 Corrosion protection of ductile iron pipes: zinc-coating

DIN 30674-4 Corrosion protection of ductile iron pipes: bitumen-coating

EN 10298 Steel tubes and fittings for onshore and offshore pipelines - internal

ISO 4179 Ductile iron pipes for pressure and non-pressure pipelines -- Centrifugal cement mortar lining -- General requirements

ISO 6600 Ductile iron pipes -- Centrifugal cement mortar lining -- Composition controls of freshly applied mortar

### Requirements

(a) Coating for steel and cast iron pipes must

1. Be applied on a properly prepared surface
2. Have sufficient adhesion to the metal surface to effectively resist underfilm migration of moisture
3. Be sufficiently ductile to resist cracking
4. Have sufficient strength to resist damage due to handling and soil stress (external coating)
5. Have high UV resistance (external coating)
6. Have high resistance against wastewater and sludge (internal lining)
7. Shall contain no toxic element or elements soluble in water, or elements susceptible to impart any smell or odour to the water (internal lining
8. Have properties compatible with any supplemental cathodic protection, in particular:

* volume resistivity of at least 1013 Ωcm
* high resistance against cathodic alkali
* protected against blistering by hydrogen at a negative potential of -1,100 mV (for aluminium or zinc anodes) or of -1,600 mV (for magnesium anodes)
* low moisture absorption and high electrical resistance (external coating)

(b) Each external protective coating must be inspected just prior to lowering the pipe into the ditch and backfilling, and any damage detrimental to effective corrosion control must be repaired.

(c) Each external protective coating must be protected from damage resulting from adverse ditch conditions or damage from supporting blocks.

(d) If coated pipe is installed by boring, driving, or other similar method, precautions must be taken to minimise damage to the coating during installation.

The Contractor shall prove all the above requirements under (a) by test certificates to be submitted to the Engineerand by onsite tests on factory applied coatings and on field joint coatings as described below.

The Contractor shall submit to the Engineera complete description of the lining and coating systems he intends to use for approval.

**(i) As external pipe coating systems may be applied:**

For steel pipe bore:

(1) Fusion bonded epoxy (FBE) plus fusion bonded polyethylene (FBPE) or polypropylene (FBPP) top coat

(2) Three-layer polyethylene or polypropylene (3-LPE / 3-LPP)

(3) Primer plus coal tar enamel (CTE) plus 2 reinforced tape wraps

For ductile iron pipe bore:

(4) Zinc sprayed and bituminous coating

For field joints:

(1/2) 100% solids rigid polyurethane solvent free spray (PU)

(1/2) Heat shrinkable sleeve

(3) Mastic plus 2 reinforced tape wraps

**(ii) As internal lining systems may be applied:**

(5) 100% solids rigid PU solvent free spray

(6) Cement mortar (only for not submerged potable water pipelines)

### Pipe Inspection

Pipe inspection shall be carried before any field coating. Pipes to be coated at manufacturers premise shall be spot checked before coating.

The pipe surface shall be inspected for surface contamination or surface imperfections. If any pipe cannot be coated, or is otherwise questionable, the Contractor shall send it back to the manufacturer.

### Pipe Surface Contamination and Removal

Surface contamination shall mean any foreign material on the pipe surface that is detrimental to the finished coating:

* Organic contaminants such as oils, lubricants, or greases.
* Previously applied coatings.
* Stencil media.
* Soluble salts.
* Adhesive type material such as tape or stickers.

Removal of the contaminants shall be accomplished by cleaning with an acceptable solvent. Criteria of acceptance for a solvent include safety considerations and ability to remove contaminant without leaving a hydrocarbon residue.

If pipe is received containing soluble salts, the pipe shall be cleaned by rinsing of pipe surface with clean fresh water and use of a phosphoric acid wash pre-treatment prior to coating.

### Coating Systems / Material

All coating materials, including repair or patch materials shall be packaged in suitable and approved containers. The containers shall be plainly marked with the name of the Manufacturer, type of material and batch or lot number where applicable. Bulk shipments shall be allowed provided the above information is included in the bill of lading.

The coating material shall be packaged in containers suitable to keep the contents clean and dry during handling, shipping and storage. Storage and handling conditions shall be in accordance with the Manufacturer's recommendations.

Precautions shall be taken during the handling, shipping and storage of all materials to prevent damage to the containers that would result in contamination of the coating materials. All contaminated or otherwise damaged materials shall be discarded.

### FBE / FBPE or FBPP Coating

FBE coatings shall be according to AWWA C 213 and comprise of 3 layers:

* 1. FBE primer, thickness min. 0.15 mm,
  2. adhesive middle layer, thickness min. 0.15 mm,
  3. FBPE or FBPP top coat, compounded with inert filler, thickness min. 1.2 mm.

The adhesive middle layer shall be designed to bond together the primer and top layer.

The FBPE/PP top coat shall be formulated to be ultra-violet (UV) resistant for a minimum of 10 years exposure.

### Three-Layer PE / PP Coating

Polyethylene and polypropylene coating shall be according to DIN 30670 and comprise of 3 layers:

* 1. electrostatically applied epoxy powder primer, thickness min. 0.2 mm,
  2. chemically modified adhesive applied by extrusion method, thickness min. 0.4 mm,
  3. polyethylene or polypropylene top coat applied by extrusion method, thickness min. 3.0 mm.

The PE/PP top coat shall be formulated to be ultra-violet (UV) resistant for a minimum of 10 years exposure.

### CTE Coating

CTE coating shall be according to AWWA C 203 and comprise of 4 layers:

* 1. Synthetic primer, thickness min 0.1 mm
  2. Coal tar enamel, thickness min 3.0 mm
  3. Resin-bonded glass fibre inner wrap, thickness min 3.0 mm
  4. Coat tar saturated resin-bonded porous glass fibre outer wrap, thickness min 6.0 mm

### Zinc and Bituminous Coating

Zinc coating materials shall be either metallic zinc with a content of at least 99%, or zinc-rich paint containing at least 85% zinc in dry film. Zinc coating shall conform to DIN 30674-3. The minimum thickness shall be 40 μm. The minimum application rate shall be 600 g/m2.

Metallic zinc-coatings shall be applied at the factory by projecting small droplets of zinc heated to the molten state by means of spray-guns.

Zinc-rich paint coatings shall be applied at the factory by spraying or brushing zinc-rich paint onto the pipe surface.

After zinc-coating, the pipe shall be given a finishing coat based on bituminous products according to DIN 30674-4 compatible with zinc, applied by any proven procedure such as gun-spraying or brush-coating. The mean thickness of the finishing layer shall be not less than 1 mm.

### PU Spray Coat for Field Joints

The PU spray system shall conform to prEN 10290 and shall provide a single high-build layer of robust, abrasion resistant polyurethane coating with a minimum thickness of 3 mm. The PU spray system shall guarantee an excellent adhesion to both the pipe substrate and PE/PP factory coating overlap areas.

### Heat Shrinkable Sleeve for Field Joints

Heat shrinkable sleeves shall be designed to provide moisture penetration resistance and corrosion prevention for pipeline field joints and shall comply to DIN 30672.

Heat shrinkable material shall be fabricated from irradiated cross-linked polyolefin pre-coated with a epoxy primer and a hot-melt adhesive (mastic).

The sleeves shall shrink when heated and force the mastic (or adhesive) to flow into the irregularities of the weld.

The shrinking action shall provide a simple, reproducible delivery system for the mastic or adhesive.

When shrunk, the polyolefin sleeve shall provide penetration and abrasion resistance during handling, backfill, and operation of the pipe and shall provide resistance against soil stresses, alkalis, acids, microbes and fungi.

Heat shrinkable sleeves shall be self priming in nature and shall be bondable substrates including heavy wall pipes, polyethylene, epoxy powder and bituminous coatings.

### Mastic

Mastic shall consist in mineral aggregate and fillers in which the voids in the mineral matrix are overfilled with the adhesives. At ambient temperature, mastic shall be highly viscous under long-duration loading and shall have elastic behaviour when subjected to short-duration loading. Mastics shall be amorphous, pressure sensitive, and tacky, so they bond easily to substrates upon contact and pressure.

Adhesives for “cold mastic” shall be based on butyl rubber, polyisobutylene, synthetic rubbers, or asphalts and shall be self-priming. The material shall have “cold flow” characteristics thus being self-healing in the event of a puncture.

Adhesives for “hot mastic” shall be based on bitumen and admixtures in portions and characteristics as needed. Typically hot mastic consists of petroleum hydrocarbons with additives to displace water, inhibit corrosion, enhance adhesion and control flow.

“Marine mastic” shall be a blend of petrolatum, inert fillers and expanded polystyrene beads, and special wetting additive to enable the product to be used in submerged marine applications. “Marine mastic” shall be non-setting and non-hardening, and shall give neutral buoyancy.

### Reinforced Tape Wraps for Field Joints

Glass fibre reinforced coal tar enamel wrapping shall comply with DIN 30672 and shall comprise of:

a) Mastic

b) Inner tape wrap consisting of hot applied, mineral filled coal tar, reinforced with an inner layer of 50 g/m2 glass tissue, spirally wound with overlap, separated from the pipe surface by at least 1 mm thickness of enamel giving a minimum finished thickness of 3.0 mm.

c) Outer tape wrap consisting of coal tar impregnated, longitudinally reinforced with glass fabric spirally wound giving a minimum finished thickness of 6.0 mm.

Factory tape application shall only be applied using a winding machine.

### Solids Rigid Polyurethane Internal Lining

PUR coatings shall be according to AWWA C 210 and DIN 30671. Thickness of liner shall not be less than 0.5 mm. PUR shall consist of two components: one isocyanate-rich solution and one polyol-rich solution (ASTM D 16 Type V) bonded together rapidly by exothermic polymerisation and then forming a solid film after application.

### Cement Mortar Internal Lining

Cement mortar for internally lining water supply pipes shall contain no toxic element or elements soluble in water; neither shall it contain elements susceptible to impart any smell or odour to the water. The characteristics of the mortar, it’s placing and control shall be in compliance with DIN 2880 and DIN EN 10298. The mortar shall consist of at least one part of Portland cement by weight to 3.5 parts of sand by weight, i.e. a sand / cement ratio smaller than or equal to 3.5. The water cement ration shall not exceed 0.42.

Cement mortar for internally lining sewage pipes shall have a sulphate resistant cement according to DIN 2614.

Thickness of liner shall not be less than 10 mm.

### Surface Preparation

Before blasting, all oil, grease, mill lacquer and other deleterious material on the surfaces of the metal to be coated shall be removed by suitable means.

In cold weather or any time when moisture tends to collect on the steel, the pipe shall be uniformly warmed for sufficient time to dry the pipe prior to cleaning. The pipe temperatures shall be maintained at least 3°C above the dew point during the cleaning and coating operations. Pipe temperature shall not exceed 70°C as a result of preheat.

Pipe surfaces shall be blast cleaned to a blast metal finish. The grade of derusting shall comply with ISO 8501-1 SA 2½. Certain coating systems require a greater degree of cleanliness; in such cases, the degree of cleaning shall be as required by the coating system.

Following cleaning and prior to coating the pipe, abrasive remaining on the outside and loose contamination on the inside of the pipe shall be removed by air blast, vacuum or other suitable methods. If air is used, the air should be dry and free of contaminants, and all particles removed from the surface shall be collected in such a manner as not to contaminate clean pipe.

Following cleaning and prior to coating, the pipe surface shall be inspected for adequate cleaning and surface condition. Pipe not properly cleaned shall be rejected and recleaned.

Blast cleaned pipe surfaces shall be protected from conditions that would allow the pipe to flash rust before coating. If flash rusting occurs, affected pipe shall be re-cleaned.

## Field Coating Application

### Priming

Immediately after cleaning, all blasted surfaces shall be free of dust, grit and other foreign material and shall be primed by brushing, spraying or other suitable means to produce an effective bond between the metal and subsequent coating. No primer shall be applied to a wet surface.

The use of primer that becomes contaminated with foreign substances or has thickened through evaporation of the solvents shall not be permitted.

The minimum and maximum allowable drying time of the primer between application of primer and application of the coating shall be in accordance with instructions issued by the Manufacturer of the primer. If the coating is not applied within the maximum allowable time after priming as required, the pipe shall be re-cleaned and re-primed.

After application, the primer coat shall be uniform and free from floods, runs, sags, drips or bare spots. Any bare spots shall be re-primed. All runs, sags, floods or drips shall be removed by brushing or scraping and the bare areas, if any, shall be retouched. Suitable measures shall be taken to protect wet primer from contact with moisture, dust or other foreign matter.

### CTE Application

Coating materials may be delivered in hot bulk or solid forms. The coating shall be heated in approved heating kettles equipped with accurate and easily read thermometers, mechanically agitated, and covered with proper lids.

The coating shall be maintained moisture and dirt free at all times prior to and at the time of heating and application.

The coating shall be loaded into the kettles in pieces of suitable size for the melting equipment used. When the Contractor receives hot material in bulk, the holding kettles shall be operated in accordance with the Manufacturer's instructions.

In heating the coating material, the charge will be melted and brought to application temperature without injury to the coating material. The temperature of application shall not exceed that which is recommended by the Manufacturer.

The primed pipe surface shall be dry and clean at the time the coating is applied.

External coating shall be applied by spraying, flooding, or pouring in such a manner as to maintain the specified thickness. The coating shall overlap the preceding spiral, producing a continuous coat free from defects.

### Application of Tape Inner Wrap

The inner wrap shall be applied directly onto the primed pipe surface with appropriate dispensing and tensioning equipment.

The inner wrap shall be spirally applied with overlap widths and application tensions required and/or recommended by the Manufacturer. The minimum overlap shall not be less than 1 cm. The minimum overlap at the end of a roll of tape shall be 15 cm or more.

The applied inner wrap shall conform tightly to the pipe surface, shall be free of voids and wrinkles and shall be smooth.

When a new roll of tape is started, the end lap of the splice shall overlap the previous roll. This splice shall be smooth and placed so as to maintain the continuity of the inner wrap coating.

### Application of Tape Outer Wrap

The outer wrap is applied directly over the inner wrap using the same type of mechanical tape tensioning equipment.

The overlap of the outer wrap shall not be applied directly over the lap of the inner wrap under any circumstances.

The outer layer may be applied at the same time as the inner layer.

### PU Spray Coat for Field Joints

PU spray coating shall be carried out by a hydraulic airless high pressure PU machine to guarantee an excellent material mix.

### Heat Shrinkable Sleeve for Field Joints

To ensure mastic fluidity and full adhesive bonding the field joint area must first be pre-heated, to between 60-230°C, depending on the mastic type, prior to sleeve installation. Heat induction shall guarantee rapid, uniform heating around the full 360 degree pipe circumference and over a controlled bandwidth by a "direct-to-metal" non-contaminating heat source, which ensures total mastic fluidity without over/under heating.

Sleeve shrinkage by manual gas torch heating methods shall only be applied for other than circumference weld seams. Sleeves shrinkage shall then be accomplished by using manual gas torch heating methods. Shrinking shall start at the top centre of the sleeve working toward one end. The torch shall be moved to avoid burning the sleeve. After this, shrinking shall continue circumferentially from the centre to the opposite end. The sleeve has conformed to the pipe when mastic flow is evident at the sleeve edges. Once fully shrunk the sleeve shall be 'rolled' to remove any residual air pockets at the mastic / substrate interface, typically found around the weld bead and factory coating edges.

### Hot Mastic for Field Joints

Mastic mix materials shall be heated in a re-melt kettle to a temperature of approximately 175 to 190°C or as specified by the manufacturer. Cooling shrinkage may be kept to a minimum if material temperatures are held to the suggested range.

In charging the re-melt kettle, the mastic level shall be maintained such that the paddle blades are visible at the top of their rotation. The unit may be used as a continuous mixer by charging the cold material from the back end while drawing hot material from the gate.

Accurate portable thermometers shall be readily available and used for checking mastic temperatures prior to moulding.

If it should become necessary to hold mastic mix material in the kettle for an unusual length of time, the lid should be closed, the fire decreased and a small amount of asphalt added to replace asphalt driven off by the continued application of heat.

The mastic mix form, or mould, shall consist of a pre-cut section of sheet metal wrapped over the field joint mould area and extending back over the plant applied concrete coating, if any. The form shall be securely strapped or banded at each end.

The pre-cut opening at the top shall be opened and mould shall be filled with mastic mix, being carefully agitated or vibrated and formed to assure complete filling and the elimination of voids or honeycomb within the joint. After filling the mould, the opening shall be strapped shut and at this time water cooling may be used. The number of straps or bands shall be chosen dependent upon the size or weight of the joint being installed.

### Tape Coating Field Joints, Fittings, Connections

Primer respectively mastic shall be applied according to the above Sub-clauses.

Strips of wrapper shall be cut according to size of pipe (multiple strips may be required to cover the entire patch area). Length of wrapper should be 4 times the diameter of the pipe.

The wrapper shall be slipped under pipe and ends shall be pulled above pipe on both sides, leaving about 2.5 cm distance from bottom of pipe to wrapper.

Molten mastic shall be poured on top 1/4 of pipe from one side of pipe to other. Mastic will flow down and around the pipe surface.

When mastic moves to the bottom of the pipe, the wrapper shall be seesawn loosely with an upward and downward motion to assure proper thickness.

The wrapper shall be pulled around the hot mastic tightly. A spot of mastic shall be poured on top to stick wrapper to overlap together.

## Inspection and Testing

The entire procedure of applying the protective coating material as herein specified shall be inspected either at manufacturer’s premise or onsite. Improperly coated pipes shall be repaired. In case repair is not sufficient, the Engineershall have the right reject the poorly coated pipe. Re-coating or coating repair that may be necessary shall be done at the Contractor’s expense.

### Coating Thickness Measurements

An appropriate and calibrated film thickness gauge shall be used to perform coating thickness measurement.

The coating thickness shall meet or exceed the agreed upon minimum coating thickness. All joints which fail to meet the minimum coating thickness test shall be re-coated or repaired.

### Electrical Inspection

Holiday inspection of the entire coated surface shall be performed with an approved high voltage Holiday Detector to indicate any flaws, holes, breaks or conductive particles in the protective coating.

The Holiday Detector shall have sufficient D.C. voltage and be equipped with a positive signalling device. The search electrode shall be made of conductive rubber, or other applicable material. The Holiday Detector shall be operated in such a way as to audibly and/or visually detect the presence of all holidays.

The voltage to be used shall not exceed 5 kV/mm of nominal coating thickness. If a low voltage, wet sponge type, detector is used, the test voltage shall be 2.5 kV/mm.

## Repair Procedures

All defects disclosed by the holiday detector and other obvious defects shall be repaired by the Contractor.

Areas of repair to the coating shall be holiday inspected by the Contractor on a 100% basis. Repairs shall be inspected by holiday testing

The damaged coating shall be removed from the steel surface. The edge of the cured coating adjacent to the damaged area shall be "feathered" and coated with an appropriate surface conditioning solvent recommended by the coating Manufacturer. This solvent shall be applied in accordance with the Manufacturer's recommendations.

The damaged area shall then be re-coated.

### FBE Coating

Small holidays in FBE coatings may be patched by use of a two part, 100% solids, liquid epoxy compound specified by the Manufacturer. The damaged area shall be abraded by hand filing or use of carborundum cloth. Application shall be made to a minimum thickness of 0.6 mm and shall overlap the undamaged area a minimum of 1.5 cm. The liquid patch compounds shall not be applied when the pipe temperature is below 10°C unless provisions are made for heat curing the patch material using methods and temperatures in accordance with procedures recommended by the coating Manufacturer.

### Tape Systems

All holidays detected such as damaged or flawed areas shall be repaired by peeling back and removal of the outer and inner layers from the damaged area.

The holiday area shall then be brushed with primer and a patching tape with a polyethylene backing and butyl adhesive should be applied directly to the defective area in the manner specified by the Manufacturer.

The minimum lap at the damaged area shall be 10 cm all around.

The repaired area shall be tested with a Holiday Detector after the repair is completed.

The repaired area may be covered in cigarette wrap fashion with the outer wrap to a minimum lap of 10 cm beyond the patching tape.

### Cement Linings

Repairs shall be carried out as follows:

1. The damaged lining shall be cut out to the metal. Edges shall be squared.

2. The cut-out area and adjoining lining shall be wetted.

3. With the damaged area cleaned and the adjoining lining wet, mortar shall be spread evenly over the area to be patched in the lining thickness of the surrounding cement liner. After the lining has become firm and adheres well to the surface, it shall finish with a wet paint brush or similar soft bristle brush.

4. The repaired lining shall be kept moist by tying canvas or wet burlap over the ends of the pipe or fitting for at least 24 hours. As an alternative the repaired lining may be seal coated with a cut back type of asphaltic seal coating. This must be sprayed or brushed on within 5 to 30 minutes after lining.

The repair cement shall comply with these Technical Requirements. Mortar for lining shall not be used after it has been mixed for more than 1 hour. Too rapid loss of moisture from fresh linings due to hot weather or high wind shall be prevented by appropriate curing measures.

### Coated Pipe Handling, Storage and Loading Requirements

Pipe shall be stored, handled and transported in a manner to prevent damage to the pipe walls, bevelled ends and the coating.

Storage racks shall be so designed as to protect the coated pipe from standing water, direct soil contact, and sharp or hard objects that might damage the coating.

The coated pipe shall be shipped using sufficient and proper dunnage to adequately protect the pipe and coating.

## Ductile Iron Pipes

### Standards

The Contractor shall carry out the works described in accordance with the appropriate standards or equivalent local or international standards. The main standards are, but shall not be limited by the following: [new]

EN 10242 Threaded pipe fittings in malleable cast iron

DIN 28601 Ductile iron pipes and fittings - Screwed socket joints

DIN 28603 Ductile iron pipes and fittings - Push-in joints

EN 545 Pipes, fittings and accessories made of ductile cast iron for water pipes, requirements and test procedures

EN 598 Ductile iron pipes, fittings accessories and their joints for sewerage application, requirements and test methods

ISO 2531 Ductile iron pipes, fittings, accessories for pressure pipelines

ISO 6594 Cast iron drainage pipes and fittings - Spigot series

EN 10204 Metallic products - Type of inspection documents

Ductile cast iron pipes shall be used exclusively within the fields of water supply, sewerage and waste water treatment works.

### Material

All pipes and fittings and accessories shall be made from ductile cast iron, also called nodular or spheroid graphite cast iron, characterised by the presence of graphite in the spheroid state in sufficient quantities to impart the mechanical characteristics defined in the respective standards.

Pipes, fittings and accessories must not have any defects likely to be detrimental to their use.

The tolerances on thickness and on masses shall not exceed the tolerances given in ISO 2531.

### Maximum Working Pressure and Internal Pressure Proof Test

Pipes shall be subjected to a works hydraulic test for a duration of 300 seconds at a minimum pressure as shown in the following table:

|  |  |
| --- | --- |
| Nominal Diameter ND [mm] | Works Test Pressure [bar] |
| 80 to 300  350 to 600  700 to 1000 | 50  40  32 |

## Joints

### Socket and Spigot Pipes

All buried pipes shall, unless otherwise indicated, be of the socket and spigot type with coatings as specified above. The joint to be used shall be the automatic standard joint. This joint is used to connect two pipes, which terminate respectively in a socket and a spigot. The joint is made watertight by the compression of a rubber gasket.

At changes in direction (bends) or nominal diameter (reducers) and when branching (tees) is constructed or at pipeline ends (blank flanges) joints shall provide restraint if the pipe is not secured according to Sub-clause 16.7 Thrust Blocks.

On the inside of the socket are:

* a deep recess with annular seating faces for the gasket,
* a long cavity which allows for angular and longitudinal movements,

of the adjoining pipes.

The gasket consists of a substantial body, which is extended into two thick lips directed towards the bottom of the socket. The outer edge of the body is formed into an annular shoulder, which fits into the recess in the socket, the side of the shoulder facing the entry to the socket is given a chamfer which centres the gasket in its recess.

The standard gaskets are moulded components with a generous cross section providing large seating surfaces to ensure fluid tightness and a substantial reserve of elasticity. Watertight gaskets shall be used for pipelines carrying cold water or sewage. The maximum continuous working temperature for these gaskets is 70°C. Homogenous gaskets for ND 60 to 1000 are natural rubber or an equivalent elastomer.

The storage conditions for the gaskets are:

the storage temperature should be between +5°C and +25°C. If they are stored at low temperature, care should be taken not to deform gaskets when handling them. They should be brought to about 30°C for long enough to give them original flexibility before being used.

For vulcanised elastomer based products the following should be avoided.

* storage in a too damp or too dry atmosphere
* direct sunlight or high ultra-violet artificial light
* protect them from ambient air and the especially harmful effects of ozone

### Flanged Pipes

All non-buried pipes (in pumping stations, etc.) shall, unless otherwise specified, be flanged pipes with internal coatings as specified above. The external coating shall be the factory coating specified above, excluding the bitumen, supplemented by a number of paint coats as specified in these Technical Requirements”Coating”, with a finishing coat of a colour to be specified by the Engineer.

Flanged pipes shall be horizontally cast pipes with flanged sockets or spigots, flanges drilled to gauge NP 10 or NP 16 and according to the standards specified in these Technical Requirements.

Junction to socket and spigot pipes shall be made by inserting a flanged socket piece.

### Fittings

Fittings shall comply with ISO 2531 with wall thickness designed for a K-value of 14 for tees and K= 12 for all other fittings. Flanged fittings shall be drilled to gauges NP 10 or NP 16 as stated for pipes above. The fittings shall be submitted at the works to a leak-tightness test carried out with water at the pressures indicated below:

| Nominal Diameter ND [mm] | Hydrostatic Leak Test Pressure [bar] |
| --- | --- |
| 80 to 300  350 to 600  700 to 1000 | 25  16  10 |

## Coating

### Pipes for Water Supply

Pipes for water supply shall be lined internally with spun cement mortar. The mortar shall contain no toxic element or elements soluble in water, neither shall it contain elements susceptible to impart any smell or odour to the water. The characteristics of the mortar, its placing and control shall be in compliance with DIN 2880 and DIN EN 10928. The mortar shall consist of at least one part of cement by weight to 3.5 parts of sand by weight, i.e. a sand / cement ratio smaller than or equal to 3.5. The water cement ratio shall not exceed 0.42 and the quality control shall be performed in accordance with ISO 6600.

All pipes of ND 250 or smaller shall have an external electrolytic zinc protection. In addition all pipes shall have an external coat of black varnish applied at the factory in accordance to DIN 30674-3.

### Pipes for Pumped Sewage

Ductile iron pipes for pumped sewage have to be lined with an inner sulphate resistant cement lining according to DIN 2880, DIN EN 10928 and DIN 2614.

All pipes of ND 250 or smaller shall have an external electrolytic zinc protection. In addition all pipes shall have an external coat of black varnish applied at the factory in accordance to DIN 30674-3.~~.~~

### Bends and Tees

Bends and tees shall be lined inside with epoxy as specified for accessories and coated outside as specified above for pipes.

## Transport and Storage

During transport pipes shall be solidly supported not only under the lower layer and between the layers, but also laterally and at the ends and the top in wooden crates to prevent accidental damage. Storage on site shall be on a raised floor with support frames so that the sockets do not touch the ground. Storage can be either head to tail storage or all pipes pointing in the same direction. The storage of all pipes shall be carried out in strict accordance with the manufacturer’s instructions.

## Re-Rounding and Cutting of Pipes

Pipes, which have been roughly handled, can have an ovalisation at the spigot end, which prevents a correct assembly of the pipeline. Such ovalisation may be corrected with special tensioning equipment to the approval of the Engineer. The application of correction methods has to ensure that no damage will be caused to the preventive coating of the pipes.

In general no cutting of ductile iron pipes, fittings and accessories on site is allowed. All delivered pipes shall provide a thoroughly proper preventive coating according to the defined requirements.

## Laying and Jointing

Laying of pipes shall generally be in accordance with the requirement as specified in DIN EN 1610, in these Technical Requirements and with the instruction of the manufacturer.

The pipes shall be laid in straight lines both in horizontal and vertical planes. Changes of direction of less than 11.25° shall be obtained by deviating the pipes after jointing at one or more joints. The angle of deviation at each joint depends on the ND and has the following maximum values:

|  |  |
| --- | --- |
| **Nominal Diameter ND** [mm] | **Maximum Deviation** |
| 100 to 150  200 to 300  350 to 500  600 to 700  800 to 1100 | 5°  4°  3°  2°  1°30’ |

No deviation can be made at a locked joint.

The general jointing procedure may vary with the type of joint used, but the basic requirements are:

* Overall cleanliness
* Correct positioning of the components
* Correct centring of the spigot in the socket
* Strict observance of the manufacturer’s assembling instructions

The Contractor shall be responsible for providing the necessary copies of these instructions.

## Steel Pipes, Pipe Laying and Testing

### Standards

The Contractor shall carry out the works described in accordance with the appropriate standards or equivalent local or international standards. The main standards are, but shall not be limited by the following:

**Steel Pipes**

DIN 2460 Steel water pipes and fittings

EN 805 Water supply - Requirements for systems and components outside buildings

EN 10216 Seamless steel tubes for pressure purposes; technical delivery conditions

EN 10217 Welded steel tubes for pressure purposes; technical delivery conditions

EN 10220 Seamless and welded steel tubes - Dimensions and masses per unit length

EN 10224 Non-alloy steel tubes and fittings for the conveyance of water and other aqueous liquids

EN 10226 Pipe threads where pressure tight joints are made on the threads

EN 10255 Non-Alloy steel tubes suitable for welding and threading

EN 10296 Welded circular steel tubes for mechanical and general engineering purposes

EN 10297 Seamless circular steel tubes for mechanical and general engineering purposes

**Fittings**

EN 10241 Steel threaded pipe

EN 10253 Butt welding pipe fittings

**Steel Names and QC standards**

EN 10027 Steel names and numbers

EN 10204 Inspection documents supplied to the purchaser for the delivery of iron and steel products

**Material Tests**

EN 10002 Metallic materials; Tensile test

EN 10003 Metallic materials; Brinell hardness test

EN ISO 6508 Metallic materials; Rockwell hardness test

EN ISO 8491 Metallic materials; tube test

**Corrosion Protection**

DIN 2880 Cement mortar inside lining for ductile cast iron and steel pipes and fittings, application

DIN 30670 Wrapping of steel pipes, PE

DIN 30675 Outer corrosion protection of buried pipes, steel pipes

EN 10286 Steel tubes and fittings for on and offshore pipelines - External three layer extruded polypropylene based coatings

EN 10287 Steel tubes and fittings for on and offshore pipelines - External fused polyethylene based coatings

EN 10288 Steel tubes and fittings for on and offshore pipelines - External two layer extruded polyethylene based coatings

EN 10928 Cement mortar inside lining for ductile cast iron and steel pipes and fittings, requirements

BS EN 22063 Metallic and other inorganic coatings : thermal spraying : zinc, aluminium and their alloys

**Welding General**

DIN 1910 Welding

EN 287 Approval testing of welders

EN 288 Specification/and Qualification of Welding Procedures for Metallic Materials.

EN ISO 14731 Welding coordination - Tasks and responsibilities

EN 729 Quality Requirements for welding of metallic materials

EN 1011-1 Welding - Recommendations for welding of metallic materials - Part 1: General guidance for arc welding

EN 25817 Welding - Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) - Quality levels for imperfections

EN 29692 Specification for metal-arc welding with covered electrode, gas shielded metal arc-welding and gas welding. Joint preparation for steel

Welding Consumables

DIN 1913 Welding electrodes

EN 440 welding consumables : wire electrodes and deposits for gas shielded metal arc welding of non-alloy and fine grain steels : classification

EN 499 Welding consumables - covered electrodes for manual metal arc welding of non alloy and fine grain steels - Classification

EN 756-760 Welding consumables

EN 1668 Welding consumables - Rods, wires and deposits for tungsten inert gas welding of non alloy and fine grain steels - Classification

EN 12074 Welding consumables - Quality requirements for manufacture, supply and distribution of consumables for welding and allied processes

EN 12536 Welding consumables - Rods for gas welding of non alloy and creep-resisting steels - Classification

EN 20544 Welding consumables - Technical delivery conditions for welding filler metals - Type of products, dimensions, tolerances and markings

**Welding Tests**

EN 895 Destructive tests on welds in metallic materials - Transverse tensile test

EN 910 Destructive tests on welds in metallic materials - Bend tests

EN 970 Non destructive examination of fusion welds: Visual examination

EN 1289 Non destructive examination of welds: Penetrant testing of welds: Acceptance criteria

EN 1290 Non destructive examination of welds: Magnetic particle testing of welds: Method

EN 1291 Non destructive examination of welds: Magnetic particle testing of welds: Acceptance criteria

EN 1435 Non destructive examination of welds: Radiographic examination of welded joints

prEN 1711 Non destructive examination of welds: Eddy current examination by complex plane analysis

EN 1712 Non destructive examination of welds: Acceptance criteria for ultrasonic examination of welded joints

EN 1713 Non destructive examination of welds: Characterisation of imperfections in welds

EN 1714 Non destructive examination of welds: Ultrasonic examination of welded joints

EN 10246 Non-destructive testing of steel tubes

EN ISO 17635 Non destructive examination of welds: general rules for metallic materials.

EN 12517 Non destructive examination of welds: Acceptance criteria for radiographic examination of welds

EN 29302 Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes; electromagnetic testing for verification of hydraulic leak-tightness

EN 29303 Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes; full peripheral ultrasonic testing for the detection of longitudinal imperfections

Steel pipes and fittings shall be factory made. Factory welding of longitudinal and spiral seams shall be an automatic submerged arc welding process, except for smaller pipe diameters as detailed under Manufacture in this clause. The ends of pipes, fitting and specials shall be fully prepared for jointing by the specified method, prior to delivery to site.

Internal and external corrosion protection systems shall normally be applied at the factory. Pipes and fittings shall be supplied to the site with adequate quantities of materials to permit the completion of the protection systems at welded joints on site.

### Materials and Dimensions

All pipes, and fittings and accessories shall be made from steel of quality to impart the mechanical characteristics defined in the respective standards.

The following strength classes shall apply:

|  |  |  |
| --- | --- | --- |
| EN 10027-1 | EN 10027-2 | old German name |
| L245 | 1.0418 | St E 240.7 |
| L290 | 1.0429 | St E 290.7 |
| L320 | 1.0430 | St E 320.7 |
| L360 | 1.0578 | St E 360.7 |

Pipes, fittings and accessories must not have any defects likely to be detrimental to their use.

The tolerances on thickness and on masses shall not exceed the tolerances given in DIN 1626 and DIN 1629.

Pipe Lengths:

Steel pipes shall be supplied in lengths as follows:

* Shortest pipe 8.5 m
* Min. acceptable average length 12.0m
* Longest pipe 14.0 m

### Sampling, Inspections and Tests

For sampling purpose, the pipes shall be batched as follows:

* Pipes ≤ 500 mm 100 pipes or up to 100 pipes
* Pipes > 500 mm 50 pipes or up to 50 pipes

From each batch, one pipe shall be selected for destructive testing as enumerated below, before testing the samples shall undergo a heat treatment at 250°C for 6 hours:

Tensile tests to be performed on one sample cut from the parent material, and one sample perpendicular to the weld seam and containing the weld seam.

Bending tests to be performed on two samples cut perpendicular to the weld seam and containing the weld seam. The bending tests shall be made by bending the sample through 180° around a mandrill having a diameter of three times the pipe wall thickness. After bending, the sample shall show no crack in the weld material, or between weld material and base metal, with a dimension exceeding 3 mm. Alternatively, if cracking or fracture does occur, the sample shall be opened and the fracture surfaces examined. The sample will be regarded as having passed the test if the fracture surfaces show no gas pockets or slag inclusions having any dimension exceeding 2 mm.

Flattening tests for pipes of nominal diameter exceeding 50 mm and not exceeding 150 mm shall have tests rings not less than 40 mm cut from them and flattened between parallel plates. Any weld in the sample shall be positioned at the point of maximum banding, and shall show no sign of fracturing until the distance between the plates is less than 75% of the original outside pipe diameter. No sign of fracture in the base material shall occur until the distance between the plates is less than 60% of the original outside diameter

Non destructive testing shall be performed as follows:

* Impermeability tests of all pipes,
* Surface inspection of all pipes,
* Non destructive inspection of all pipes,
* Dimensional inspection of all pipes.

The tensile testing shall be made in conformity with the standards. The bending tests shall be made in conformity with the standards and the sample shall be bent through an angle of 180°. Non destructive inspection shall be in accordance with the standards.

The impermeability tests shall take place at a testing laboratory to be approved by the Engineer. The test shall take place at room temperature, 20°C ±2°C, with an applied water pressure of 5 MPa for a minimum of 5 hours. The test shall take place before the pipe is isolated and the test reports shall be submitted to the Engineerfor approval. The Contractor shall bear all costs of the impermeability testing.

### Marking, Tolerance Class and Certification

The following markings shall be made in white reflective weather resistant paint one end of the pipe:

* Manufacturer's mark
* Contract identification number
* Material grade
* Outside diameter and wall thickness
* Length of pipe in meters to two decimals
* Pipe number (individual and selected consecutively, no two pipes shall bear the same number). The pipe number shall ensure full traceability to test reports
* Tolerance symbols for pipes ≥ 500 mm

The pipe certification package shall comprise the Manufacturer's Certified Test Reports and inspection certificate (i.e. certified to EN 10204/3.1B or equivalent ) including, when required, Independent Inspectors Reports and third party certificates, all marked with the supply contract number and containing:

* Heat and product analysis results.
* Mechanical test results.
* Non destructive examination reports with a statement of method used.
* Statement of compliance with visual and dimensional checks.
* Statement of manufacturing process and type of heat treatment.
* Statement of compliance with hydrostatic test requirements including test pressure.
* Inspection certificates and reports for surface treatments

### Transport, Storage and Stringing of Pipes

All equipment necessary for loading, transport to construction sites or storage sites and unloading shall be supplied by the Contractor.

Pipes shall be handled in such a way that damage is avoided as far as possible. They shall only be lifted with straps of a material and a form which protects the pipes and their coating from damage. The Contractor shall check the pipes for any visible defects or damage and notify the Engineerif any are found. The Contractor shall be responsible for making good any damage or defect to the approval of the Engineer.

All pipes shall be protected from weather, including sunlight, and fouling during transport, storage and stringing. If any pipe gets fouled, it shall be cleaned before installation.

The Contractor shall be responsible for obtaining all necessary permits for transporting the pipes.

Wherever necessary, the Contractor shall ensure that any weight restrictions on public roads are not exceeded. The Contractor shall be responsible for making good any damage caused to these roads.

When pipes are collected from a storage site, the Contractor shall secure the remaining pipes against slippage. When a storage site is emptied of materials the Contractor shall clean the site and any access road and reinstate both to their original condition.

The pipes shall be strung consecutively along the working width on timbers or similar, with at least two per pipe, to avoid damaging or fouling the pipes. The pipes shall be strung in such a way that the normal use of the surrounding areas is disturbed as little as possible. Pipes shall be secured against rolling. When stringing pipes with diameter tolerance marks, only ends with the same mark shall abut.

### Pipe Laying

Laying of pipes shall generally be in accordance with the requirement as specified in DIN EN 1610, with Sub-clause 16.3 and 4.6.6 and with the instruction of the manufacturer.

### Welding of Pipelines

The Contractor shall provide all necessary personnel, equipment and materials. The equipment shall include, but not be limited to:

* Welding machines and generators suitable for pipeline welding.
* Preheating equipment which ensures uniform preheating around the whole circumference of welding ends.
* Post welds heat treatment equipment.
* Internal and external line-up clamps (the external clamp shall be hydraulically operated).
* Protective canopies (or umbrellas and wind shield collars) so that welding can be carried out even in relatively bad weather.
* Weather proof, insulating mats for the thermal insulation of girth welds (at least 1.5 x d wide).

The Contractor shall supervise the site, the welders and their work during the entire working period. For this purpose the Contractor shall use a qualified and certified welding specialist. Welding certificates shall be submitted to the Engineer.

All welding shall comply in general with EN 288, EN 719 and EN 729.

### Materials

The steel covered shall comply with the base metal specified in these Technical Requirements.

Attention shall be paid to obtaining a good working environment such as selection of low smoke developing consumables etc.

The weld filler metal selected shall give a weld metal matching the base metal properties as closely as possible. The yield strength of consumables shall neither overmatch the base material yield strength by more than one level stated in the respective standards, nor shall under matching be allowed.

### Welding Processes

Acceptable welding processes are:

* Shielded Metal Arc Welding (Stick) SMAW
* Gas Tungsten Arc Welding (TIG) GTAW
* Gas Metal Arc Welding (MIG/MAG) GMAW
* Flux Cored Arc Welding FCAW

The use of welding processes other than those listed above is permitted only with the prior approval of the Engineer. Processes may be used in combination if the same combination and sequence of processes have been qualified by the welding procedure qualification test.

### Welding Procedure Qualification

The Contractor shall submit detailed welding procedure requirements complying with the standards. All dimensions, all combinations of materials to be joined and all repair welding shall be covered by the procedure requirements. The procedure requirements are subject to the approval by the Engineer.

The Engineer may, at his sole discretion, approve the use of already established, sufficiently tested and documented procedures not more than 2 years old. Transfer of welding procedure qualification records from one contractor to another is not permitted.

For each procedure requirements and prior to start of production welding the Contractor shall carry out welding of test joints under site conditions following all of the details of the approved procedure requirements.

The qualifications test shall be carried out on steel with the highest specified minimum yield strength / maximum carbon equivalent which is expected to be covered by the Welding Procedure Requirements. All the results from the procedure qualification records shall be submitted to the Engineer for approval of welding procedures.

### Qualification of Welders and Welding Operations

Only skilled welders and welding operators who can document qualifications relevant for pipeline welding will be accepted by the Engineer. Prior to the performance of any production welding operators shall qualify for the relevant welding procedures according to EN 287.

The qualification tests are acceptable if they meet the requirements for visual examination, destructive testing and for radiographic examination as specified in the respective standards. The testing shall be carried out by an approved laboratory at the Contractor’s expense. Welder and welding operator performance test certificates shall be issued and kept on site during the whole working period.

Welder and welding operator qualification tests may be performed together with welding procedure qualification tests.

These certificates are only valid for 6 months after the last welding.

### Welding Preparation

Items material grades, wall thickness and ratings shall conform to the requirements laid down in the applicable Drawings and Technical Requirements.

Surfaces to be welded have to be sufficiently clean, to avoid deterioration of weld quality by any oxide, oil, grease or other contamination. Raw edges after oxygen cutting shall be ground to remove any residual oxides, dross, or slag. Edges before welding shall be clamped in position, preferably with mechanical devices.

Each pipe or component shall be visually inspected to ensure that it has not sustained any visually determinable damage. Disposition of damaged items shall be resolved in consultation with the Engineer.

All requirements for welding preparation contained in the qualified welding procedure Technical Requirements shall be strictly adhered to.

### Weld Pointing

Weld points shall be made by skilled welders as specified above and under conditions required for welding as specified below:

* electrodes shall be dried and conserved according to the recommendations of the producers,
* pre and post-heating shall be applied where necessary,
* length of weld points shall be greater than 30 mm.

The parent metal dilution shall be limited to avoid risk of weld metal deposited cracks. Backward welding shall be carried out at the end of each bead to properly fill the craters of welding pass end and, thus, avoid incipient cracks. Any cracked tack weld must be seriously removed before the welding operation.

Fastening of welded edges shall ensure compliance with alignment tolerances during all the welding operations.

### Welding Workmanship

All welding shall be performed by qualified welders and strictly in accordance with qualified welding procedures.

Welding shall be suspended by the Contractor when prevailing weather conditions will impair the quality of the work, e.g. airborne moisture, blowing sand, high winds or thunderstorms.

Vibration inducing operations carried out in the vicinity of welded plates are prohibited during welding operations.

Stray arching outside the weld groove is not permitted. Should stray arching outside this area occur, this shall be brought to the attention of the Engineer who may require any such damaged section to be repaired or cut out at the Contractor’s expense.

Earth connections for the welding shall always be positioned in the centre of the joint during root and cap-bead laying. They shall be mechanically or magnetically connected to the pipe.

Each pass shall be completed around the whole circumference before the next pass is started.

The position of start/stop on subsequent passes shall not be identical. Upon completion of the cap bead, the weld and the pipe surface shall be cleaned of weld spatter and other deposits, and shall then be wrapped with a dry, waterproof insulating mat to ensure a slow cooling of the weld zone and to give protection against rain.

### Cleaning after Welding

The surface shall be dry and free of oil, grease, soil and concrete residues. All loose rust and mill scale shall be removed by wire brushing immediately before welding inspection. On straight pipes brushing shall be done mechanically using sharp brushes to avoid polishing of the steel surface. Therefore a stock of readily accessible new brushes is required.

Welds fabricated with basic filler metals shall be washed with fresh water.

Cleaning by sandblasting is allowed as an alternative.

### Post Weld Heat Treatment (PWHT)

PWHT of weld seams shall only be carried out if specified in the approved welding procedure or where this is indicated in the project material. PWHT procedures shall be approved by the Engineer.

### Identification of Weld Seams

Every girthweld shall be numbered by the Contractor in accordance with a system to be specified by the Engineer. This number shall be painted on the pipe coating on one side of the joint between 0.5 m and 1.0 m from the seam together with the pipe number and pipe length to facilitate completion of the pipe book.

For each pipeline and each pressure test section, the Contractor shall fill out pre-printed forms and enter these in a pipe log. As the work progresses, the Contractor shall present the pipe log forms to the Engineer. Before the start of a pressure test the completed pipe log for the section in question shall be handed over to the Engineer.

### Closing of Pipe Ends

During welding on a pipeline segment all open ends of that segment shall be kept closed with a plug or a cap.

At interruption in the pipeline construction, the Contractor shall close the ends of the pipe strings. The closure shall be tight enough to prevent any entry of foreign matter into the pipe.

Plugs or caps must not be fixed by welding or by any other method which damages the pipe. They shall be securely attached to the pipe and shall remain in place until the string is laid.

### Welding Inspection

Examination shall be performed according to this Technical Requirements and the following codes and standards:

* Radiographic examination according to the standards.
* Ultrasonic examination according the standards.
* Magnetic particle examination according to the standards.
* Liquid penetrant examination according to the standards.
* Visual examination according to the standards.
* Hardness measurement according the standards.

The Contractor shall engage a qualified independent inspection company which shall perform, evaluate and document all welding inspection. The inspection company shall be approved by the Engineer.

All non-destructive examination shall conform to the requirement of the adequate method standard and the Technical Requirements. Procedures shall be submitted to the Engineer for approval.

### Extent of Examination

All welds shall be 100% visually examined.

Guarantee welds (welds, which will not be pressure tested) and tie-in welds shall be 100% examined by radiography as well as by ultra-sound.

All welds, which have been repaired or replaced, shall be 100% re-examined by the same methods and with the same acceptance criteria as required for the original work.

Ultrasonic examination may substitute radiography where radiographic examination is impractical and may be used as general back-up for radiography in case of interpretation/verification problems.

Socket welds and branch connection welds, which are not examined by radiography shall be examined by magnetic particle or penetrant methods to the extent stated for butt welds.

Where spot examination is required in subsequent sections, the welds shall be selected to ensure that the work of each welder and each welding procedure is included.

When required spot examination reveals defects, two additional welds, the preceding and the subsequent welds made by the same welder, shall be examined.

If one of these welds shows defects, three preceding and three subsequent welds shall be examined at the Contractor’s expense.

If five or more subsequent welds of one welder show defects, all welds of this particular welder shall be additionally examined at the Contractor’s expense.

All butt welds in piping systems with design pressure >1.6 MPa shall be examined by 100% radiography.

At least 10% of other butt welds shall be examined by radiography along their entire circumference as described above. The Engineer may specify greater extent of examination.

In particular all welding in:

* Piping containing lethal substances
* Hydrogen service piping
* Underground process piping
* Jacketed (inner) pipes

shall be examined 100% by radiography.

### Acceptance Criteria

Acceptance criteria shall be as started in the standards for the respective test method.

### Production Testing

The Engineer shall be entitled to select a number of seams for destructive testing.

The Contractor shall be responsible for cutting out the seams, bevelling the pipe ends and rewelding the joint. The destructive tests shall, unless otherwise agreed, be made in accordance with the requirements in the respective general welding requirements covering qualification tests for welding procedures.

The Contracting Authority will bear the cost of these tests, if the welds are proved to be acceptable. However, if it turns out that the seam does not comply with all the requirements, the Contractor himself shall bear the costs. In this case, the Engineer may insist on an additional seam being tested, and the costs of the testing and renewal of this seam shall be paid by the Contractor, irrespective of the results. If this seam does not comply with the requirements, the control may be further extended at the Contractor’s expense.

The extent of any such supplementary inspection work shall be decided by the Engineer with the aim of establishing in a satisfactory manner whether the welding work complies with the requirements or not.

If any change of personnel takes place during the course of the welding work, this could influence the quality of weld seams and the Engineer may require a new seam to be destructively tested at the Contractor’s expense.

###### Document Requirements

The following documents shall be submitted to the Engineer for approval:

Before examination:

* Certificates for welding personnel
* welding procedures
* Report forms

Request for deviations, if any, from specified requirements during examination:

Authorised examination reports with enclosed field reports and films.

### Other Jointing Methods

*Threads*

Steel pipes with nominal diameters up to and including 150 mm may be threaded (female or male) at both ends and provided with a detachable screwed coupling attached to one end. Threads shall comply with ISO 7 and ISO 228 standard. Couplings shall have a minimum length of 44% of the pipe diameter, plus 30 mm, and shall have parallel threads. Pipe ends shall be provided with taper threads. Couplings shall be made from similar material to that of the pipes.

*Flanges*

All non-buried pipes (in pumping stations, etc.) shall, unless otherwise specified, be flanged pipes.

Where flanges are required they shall be forging or made from steel plate meeting the steel specification of the pipe material. Flanges shall be weld-on type and drilled to the application, NP 10 or NP 16.

Flanges shall comply with the standards stated in Sub-clause 16.10 Flange Connections.

## Galvanised Steel Pipes

Except where otherwise stated, galvanised steel pipes shall be manufactured, delivered to site, laid and connected as specified in these Technical Requirements.

In Addition to the standards listed, the following standards shall apply:

EN 10240 Internal and/or external protective coatings for steel tubes - Specification for hot dip galvanized coatings applied in automatic plants

### Joints

Galvanised steel pipes and fittings shall be supplied with either flanged ends or with threaded ends.

Where flanged joints are specified for use with galvanised steel pipe and fittings the flanges shall be in accordance with Sub-clause 16.10 Flange Connections..

### Galvanising

After being tested the steel pipes and fittings shall be galvanised in accordance with EN 10240.

## Stainless Steel Pipes

The Contractor shall carry out the works described in accordance with the appropriate standards or equivalent local or international standards.

In addition to the standards listed in Part G of these Tender Requirements the following standards shall apply:

EN ISO 14175 Welding consumables - Gases and gas mixtures for fusion welding and allied processes

EN 10220 Seamless and welded steel tubes - Dimensions and masses per unit length

EN ISO 3581 Welding consumables - Covered electrodes for manual metal arc welding of stainless and heat-resisting steels

EN ISO 3506 Mechanical characteristics of jointing elements: screws, nuts, setscrews

EN 10027 Designation systems for steels

EN ISO 1127 Stainless steel tubes

EN ISO 15792 Welding consumables - Test methods

EN 10296 Welded circular steel tubes for mechanical and general engineering purposes technical conditions

EN 10312 Welded stainless steel tubes for the conveyance of water and other aqueous liquids

EN 10216 Seamless steel tubes for pressure purposes; technical delivery conditions

### Materials and Dimensions

All pipes, and fittings and accessories shall be made from stainless steel of quality to impart the mechanical characteristics defined in the respective standards.

The following stainless steel qualities shall be used according to EN 10027:

* Material No. 1.4301 (X5CrNi18-10)
* Material No. 1.4571 (X6CrNiMoTi17-12-2)

The tolerances on thickness and on masses shall not exceed the tolerances given in EN 1127.

### Welding

For welding of stainless steel pipes and fittings in general, the requirements stated in Sub-clause 16.33. (Welding of Pipelines).

Only the welding methods WIG (Wolfram-Inert-Gas) and MAG (Metal-Active-Gas) shall be applied. Only suitable equipment that guarantees a professional performance is to be used for this purpose.

The contractor has to ensure that the material combination in the area of the welding zone will not be negatively altered and that intercristalline corrosion will not develop. For this reason, only certified welding additions according to DIN 8556 and a shielded arc atmosphere shall be used that is in accordance with the material.

As far as possible, welding, edging and drilling shall be performed in the workshop under controlled conditions. Permanent protection from corrosion is to be guaranteed through a pickling treatment in the pickling bath with the correct acid consistency and temperature and through a follow-up passivation. Local pickling treatment and passivation at the construction site is only permitted in special cases. Pickling treatment and passivation have to be certified.

### Flanges

All non-buried pipes (in pumping stations, etc.) shall, unless otherwise specified, be flanged pipes.

Where flanges are required they shall be forging or made from steel plate meeting the steel specification of the pipe material. Flanges shall be weld-on type and drilled to the application, NP 10 or NP 16. Flanges shall comply with the standards stated in Sub-clause 16.10.

All of the flanged joints are to be made of suitable stainless steel material. For flanged joints deformation-proof gaskets according to DIN 2690 have to be used.

In order to avoid contact corrosion stainless steel flanges / pipes have always to be separated from any ferritic flanges / pipes by galvanically insulating screws using suitable plastic casings.

## Plastic Pipes

### PVC Pipes

The Contractor shall carry out the works described in accordance with the appropriate standards or equivalent local or international standards.

In addition to the defined standards listed in these Tender Requirements the following standards shall apply:

DIN 8061 uPVC pressure pipes quality requirements

DIN 8062 uPVC pressure pipes dimensions

DIN 8063 uPVC pressure fittings

DIN 8080 uPVC pressure pipes testing

DIN 19534 uPVC non-pressure pipes and fittings

EN 1329 Plastics piping systems for soil and waste discharge (low and high temperature) within the building structure

EN 1401 uPVC Plastics piping systems for non-pressure underground drainage and sewerage

EN 1453 Plastics piping systems for soil and waste discharge (low and high temperature) within the building structure – with structured wall

EN 1452 uPVC plastics piping systems for water supply

prEN 1456 uPVC plastics piping systems for underground drainage and sewerage under pressure

EN 1566 PVC-C Plastics piping systems for soil and waste discharge (low and high temperature) within the building structure

EN 12200 uPVC External rainwater down pipe systems

prEN 12731 PVC-C plastics piping systems for hot and cold water

PVC pipes shall be capable of withstanding ultraviolet degradation. A rodent inhibitor shall be incorporated in the material of the pipe.

The Contractor shall advise the manufacturer of the climatic and transporting conditions at the site of the Works and shall seek his advice on the storage of PVC materials on site. Subject to the Engineer’s approval this advice shall be followed at all times.

Except in the case of flanged joints and where otherwise specified or approved by the Engineerpipe joints shall be flexible and sealed with a rubber ring or gasket to the approval of the Engineerand shall withstand the various tests specified in the applicable standards. Splicing joints are not allowed.

For pipes with a nominal bore of 600 mm or less the joints shall be capable of withstanding a deflection of not less than 1.5 degrees in any direction and for pipes with a nominal bore of more than 600 mm 0.5 degrees in any direction. All pipes shall be capable of withstanding a ”draw” of 13 mm over and above the initial jointing allowance. The initial jointing allowance is the gap measured parallel to the centre line of the pipeline and shall not be less than 6 mm or more than 13 mm or as otherwise recommended by the pipe manufacturer and approved by the Engineer. Pipes and fittings shall be indelibly marked prior to laying to indicate the correct initial jointing allowance.

### PE-HD Pipes

The Contractor shall carry out the works described in accordance with the appropriate standards or equivalent local or international standards.

In addition to the standards listed in these Tender Requirements the following standards shall apply:

DIN 8074 PE HD pressure pipes, dimensions

DIN 8075 PE HD pressure pipes, dimensions

DIN 19533 PE HD/LD pressure pipes for water supply, requirements

DIN 19537 PE HD/LD non-pressure pipes and fittings

DIN 16963 PE HD fittings

DVGW W 330 German Association for Gas and Water: Guideline “Approval testing of welders”

EN 1519 PE HD/LD plastics piping systems for soil and waste discharge (low and high temperature) within the building structure

prEN 1555 PE HD/LD Gas pipe systems

prEN 12201 PE HD/LD non-pressure pipes for water supply

prEN 12318 PE-X plastics piping systems for hot and cold water

prEN 12666 PE HD/LD non-pressure pipes for sewerage

prEN 13244 PE HD/LD pressure pipes

### Welding

PE HD pipes and fittings shall be joined by heating-element butt welding.

The Contractor shall provide all necessary personnel, equipment and materials.

The Contractor shall supervise the site, the welders and their work during the entire working period. For this purpose the Contractor shall use a qualified and certified welding specialist. Welding certificates shall be submitted to the Engineer.

Only skilled welders and welding operators who can document qualifications relevant for pipeline welding will be accepted by the Engineer. Prior to the performance of any production welding operators shall qualify for the relevant welding procedures according to DVGW W 330.

Surfaces to be welded have to be sufficiently clean, to avoid deterioration of weld quality by any dirt, oil, grease or other contamination.

Each pipe or component shall be visually inspected to ensure that it has not sustained any visually determinable damage. Disposition of damaged items shall be resolved in consultation with the Engineer’s Representative.

Welding shall be suspended by the Contractor when prevailing weather conditions will impair the quality of the work, e.g. rain or thunderstorms.

Vibration inducing operations carried out in the vicinity of welding machine are prohibited during welding operations.

Welding shall be carried out only by using welding butt machines capable to weld all pipes from NP 2.5 to NP 40 according to the pipe material with the following characteristics:

* electro-hydraulic control of the pressure
* automatic pipe cut
* self aligning frame
* computer control of all welding steps after the facing operation, until the end of the welding cycle, providing easy set-up of the relevant welding data, in particular welding temperature. At the end of the cycle, a printer shall give the results of the weld with all necessary data according to international standard specifications.

After welding, the joint shall be checked visually. In case of any of the following imperfections, the pipe ends shall be cut and welded again:

* different high welding beads on pipe end
* welding beads too narrow and too tall
* welding beads too small
* crack on the centre of welding beads
* off-set too high (10% of pipes wall thickness is tolerated.

### Pipes

The Contractor shall carry out the works described in accordance with the appropriate standards or equivalent local or international standards.

In addition to the standards in these Tender Requirements the following standards shall apply:

* DIN 16868 UP-GRP wound pipes, dimensions
* DIN 16869 UP-GRP slung pipes, dimensions
* DIN 16870 UP-GRP wound pipes, requirements
* DIN 19565 UP-GRP slung pipes for wastewater
* DIN 16871 UP-GRP slung pipes, requirements
* EN 705 GRP pipes and fittings test standards
* prEN 1115 GRP piping systems for underground drainage and sewerage under pressure
* prEN 1636 GRP piping systems for non-pressure drainage and sewerage
* prEN 1796 GRP piping systems for water supply

The Contractor shall advise the manufacturer of the climatic and transporting conditions at the site of the Works and shall seek his advice on the storage of GRP materials on site. Subject to the Engineer’s approval this advice shall be followed at all times.

Stiffness shall be chosen according to the pipe static but shall not be less than 5 kPa.

Except where otherwise specified or approved by the Engineer pipes shall be jointed with push-fit couplings appropriate for the chosen design pressure. Couplings shall withstand the various tests specified in the applicable standards.

Pipes and fittings shall be indelibly marked prior to laying to indicate the correct initial jointing allowance.

### Laying Plastic Pipes

The Contractor shall submit, with his detailed designs, for the Engineer’s approval the pipe manufacturer’s complete and detailed recommendations for the handling and installation of pipes and fittings in open trench and for the building-in to structures. The Contractor shall lay pipes and fittings in accordance with the manufacturer’s installation recommendations as approved by the Engineer.

Thermoplastic pipes with a nominal bore in excess of 150 mm shall be pigged 3 months after backfilling of the pipeline has been completed and any dewatering discontinued. The pig shall be to the approval of the Engineer and shall be designed to detect deflections in the pipe which exceed the values proposed in the manufacturer’s design and approved by the Engineer. In no circumstances shall deflections exceeding 5% of the nominal bore be acceptable.

Where pipes are found to have deflected in excess of the approved limit the pipes shall be re-laid. Prior to re-laying the pipes shall be submitted for the approval of the Engineer. If the Engineer concludes that pipe is not suitable for re-laying it shall be replaced with a new pipe.

The Contractor shall provide for the Engineer’s use copies of all data relating to pipe deflections.

## 

# Steelwork

The Contractor shall carry out the works described in accordance with the appropriate national and European standards (EN). The main EN standards are, but shall not be limited by the following:

Design

EC 3 Bulding code for steel structures, EN 10025 or ISO 6706-1

EN 11590 Paints – Epoxy resin based – Used for steel structures

DIN 18800 Design and construction of steel buildings

ENV 1993 Eurocode EC 3 Design and construction of steel buildings

EN 444 Non-destructive testing - General principles for radiographic examination of metallic materials by X and gamma-Rays

Steel Products and Profiles

DIN 1025/1 I Profiles

DIN 1026 U Profiles

DIN 1028 Equal Angles

DIN 1029 Unequal Angles

EN 10024 Hot rolled taper flange I sections - Tolerances on shape and dimensions

EN 10029 Tolerances on dimensions, shape and mass for hot rolled steel plates 3 mm thick or above

EN 10130 Cold rolled low carbon steel flat products for cold forming : technical delivery conditions

EN 10131 Cold rolled uncoated low carbon and high yield strength steel flat products for cold forming

EN 10034 Structural steel I and H sections - Tolerances on shape and dimensions

EN 10048 Hot rolled narrow steel strip : tolerances on dimensions and shape

EN 10051 Continuously hot-rolled uncoated plate, sheet and strip of non-alloy and alloy steels - Tolerances on dimensions and shape

EN 10055 Hot rolled steel equal flange tees with radiused root and toes - Dimensions and tolerances on shape and dimensions

EN 10056-2 Specification for structural steel equal and unequal angles - Tolerances on shape and dimensions

EN 10067 Hot rolled bulb flats - Dimensions and tolerances on shape, dimensions and mass

EN 10140 Cold rolled narrow steel strip : tolerances on dimensions and shape

EN 10142 Continuously hot-dip zinc coated low carbon steel sheet and strip for cold forming : technical delivery conditions

EN 10143 Continuously hot dip metal coated steel sheet and strip : tolerances on dimensions and shape

EN 10147 Continuously hot-dip zinc coated structural steel sheet and strip : technical delivery conditions

EN 10149 Hot rolled flat products made of high yield strength steels for cold forming

EN 10163 Specification for delivery requirements for surface conditions of hot-rolled steel plates, wide flats and sections

EN 10169 continuously organic coated (coil coated) steel flat products

EN 10210-2 Hot finished structural hollow sections of non-alloy and fine grain structural steels. Tolerances, dimensions and sectional properties

EN 10214 Continuously hot-dip zinc-aluminium (ZA) coated steel strip and sheet: technical delivery conditions

EN 10215 Continuously hot-dip aluminium-zinc (AZ) coated steel strip and sheet: technical delivery conditions

EN 10219-2 Cold formed structural hollow sections of non-alloy and fine grain structural steels. Tolerances, dimensions and sectional properties

EN 10238 Automatically blast cleaned and automatically primed structural steel products

EN 10248 Hot rolled sheet piling of non alloy steels

EN 10249 Cold formed sheet piling of non alloy steels

Euronorm 19-57 IPE Profiles

Euronorm 24-62 IPN / UPN Profiles

Euronorm 53-62 HE A, HE B and HE M Profiles

Euronorm 56-77 Equal Angles

Euronorm 57-78 Unequal Angles

Euronorm 91 Hot-rolled wide flats - Tolerances on dimensions, shape and mass

Stainless Steel

EN 10088-1 Stainless steel index

EN 10088-2 Stainless steel technical conditions for strip and plate steel

EN 10088-3 Stainless steel - technical conditions for semi-manufactured products, rods, rolled, wires and profiles

EN 10272 Stainless steel for pressure tanks

Corrosion Protection

DIN 18364 Steel surface protection

DIN 50967 Protection of steel surfaces by galvanising

DIN 55928 Protection of steel surfaces by coating

Bolts and Fasteners

EN 20898 Mechanical properties of fasteners

EN 24014/16 Hexagon head bolts

EN 24017/18 Hexagon head screws

EN 24032-34 Hexagon nuts

Others

DIN 2310 Thermic cutting

## General

The Contractor shall fabricate, supply, deliver and erect all steelworks, fixing materials and associated parts according to the Technical Requirements and drawings and shall comply with the requirements of the relevant standards, unless otherwise specified or instructed by the Engineer.

The steelworks other than structural steelworks shall comprise of the following main items:

* Open mesh flooring and gratings including framework and supports;
* Manhole covers;
* Bar screens, weirs and accessories in overflow chambers and outfalls;
* Sheet piling;
* Anchoring;
* Step irons, ladders and pipes where shown on the approved Contractor's drawings or instructed by the Engineer;
* Staircases, landings and platforms.

For all fabricated steel works the Contractor shall submit fabrication details, and drawings and calculations required under Part G of the Technical Requirements for the approval of the Engineer prior to the manufacture of any of the items.

The structural steelworks comprise mainly the fabrication and erection of the following constructions:

* columns and beams
* gratings, including frameworks
* hatches, including frameworks
* angles for protection of edges in several lengths, including anchors
* ladders and step irons
* staircases, landings and platforms
* other structural steelwork associated with the specified mechanical and electrical plant.

Prior to any steel fabrication work, the supplier shall submit full details of his proposed procedure, qualification and methods of fabrication to the Enginee rfor approval.

This information shall include (but not be limited to) the following details where they are relevant:

* The method of plate forming
* Joint design
* Proposed welding procedure and proof of competence of welders
* Method of straightening, sizing and hydrostatic testing
* Quality control and inspection procedures.

## Quality and Testing of Materials

All steel shall be of quality to impart the mechanical characteristics defined in the respective standards.

The following strength classes shall apply:

|  |  |  |
| --- | --- | --- |
| EN 10027-1 | EN 10027-2 | old DIN Standard |
| S185 | 1.0035 | St 33 (not used) |
| S235JRG1 | 1.0036 | USt 37-2 |
| S235JRG2 | 1.0038 | RSt 37-2 |
| S235JO | 1.0114 | St 37-3 U |
| S235J2G3 | 1.0116 | St 37-3 N |
| S275J2G3 | 1.0144 | St 44-3 N |
| S355J2G3 | 1.0570 | St 52-3 N |

Should the Contractor propose to use materials, complying with Standards other than those specified above, he shall submit details of such standards. At least two weeks before ordering materials, the Contractor shall send a written notice to the Engineer giving the following details:

* type, quality and quantities to be ordered from a steel mill;
* type, quality and quantities to be ordered from available (local or non-local) stocks.

Test certificates from the steel manufacturers shall be required to be submitted to the Engineer for the materials ordered. Material obtained from stocks shall be checked by the Engineer for the exterior defects either in the workshop or at the site. Steel used for structural parts like steel tanks..., shall be tested as described in these Technical Requirements.

## Submissions by the Contractor

Prior to any steel fabrication work the supplier shall submit full details of his proposed procedure, qualification and methods of fabrication to the Engineer for approval.

This information shall include (but not be limited to) the following details where they are relevant:

1. The method of plate forming
2. Joint design
3. Proposed welding procedure and proof of competence of welders
4. Method of straightening, sizing and hydrostatic testing
5. Quality control and inspection procedures

## Drawings

Before commencing fabrication, the Contractor shall submit to the Engineer for his approval working Drawings of the steelworks. Each component shall be clearly marked.

## Calculations

The Contractor shall submit to the Engineer for his approval calculations of the following items:

* Structural calculations where applicable or required by the Engineer;
* Mounting plates;
* Stiffening parts;
* Welded seams;
* Anchors and bolts, even when these items are shown on the Drawings.

The calculations shall be in accordance with Volume 3-1 of the Technical Requirements.

In the event of unavailability of certain materials and steel sections, deviations from the original design can be made provided they are approved by the Engineer. In such cases the Contractor shall submit to the Engineer his calculation for the proposed design. Such calculations shall be submitted to the Engineer for approval in three copies together with three copies of corresponding working Drawings.

The Contractor shall submit to the Engineer for his approval calculations of weights of all relevant steel structural components. The basis for the calculations shall be the measurements of items as indicated on the approved working Drawings multiplied by their number and the specific weight of steel (= 7,850 kg/m³) or specific weight per meter and/or square meter.

These calculations shall be submitted in three copies together with three copies of corresponding working Drawings.

## Manufacturing and Workmanship

Any error in the shop fabrication, or deformation resulting from handling and transporting, which prevents the proper assembling and fitting up of parts by more than the moderate use of drift pins or by more than a moderate amount of reaming, chipping, or cutting, shall be immediately reported to the Engineer and corrected in his presence by methods which have been approved by him.

Hammering which will injure or distort the members shall not be done.

The drifting during assembling shall be only such as to bring the parts into position, and not sufficient to enlarge the holes or distort the metal. If any holes must be enlarged to admit the bolts, they shall be reamed or corrected by methods which have been approved by the Engineer.

Bearing surfaces and surfaces to be in permanent contact shall be cleaned and dry to touch before the members are assembled.

### Fabrication Tolerances

The general tolerance on all dimensions shall be ± 2 mm. Holes shall be aligned such that fasteners can be freely inserted through the members at right angles to the contact face. Where holes can be freely inserted through the members at right angles to the contact face. Where holes in members cannot be aligned without damaging or distorting the structure or (unless the Engineer shall permit) reaming the holes, the member or members shall be rejected. A structural member shall not deviate from straightness (or from the specified shape) by more than:

* 1/1,000 of the lengths between lateral restraints in the case of compression members and beams, or
* 1/500 of the overall lengths (maximum 25 m) in the case of other members.
* A structural member shall not deviate from its intended length by more than:
* 1 mm in the case of compression members faced at both ends for bearing, or
* + 0  to - 4 mm in the case of other members.

Lengths of components shall be such that cumulative variations do not prejudice the accurate alignment of the completed structure.

### Dissimilar Metals

Where dissimilar metals are used in close proximity to structural steel members or their connections, contact between such metals and the steel shall be avoided unless the Contractor can demonstrate to the satisfaction of the Engineer that contact between the dissimilar metals will not lead to galvanic corrosion.

Contact between aluminium or aluminium alloy and galvanised mild steel will be permitted. For fixing aluminium to steel structures, bolts, nuts, washers and screws shall be galvanised.

Where galvanised parts might otherwise become sacrificial anodes to the main structure, or where the electrolytic potential difference exceeds 250 mV, the parts shall be separated by an insulating medium of adequate strength.

### Preparatory Operations

Cutting and shot blasting shall be carried out in covered and well equipped workshops.

Cutting at edges of steel sheets and angles will only be accepted if these edges are to be welded into a connection and fully melted during welding. Burr-sides and sharp edges caused by cutting or sawing shall be removed by means of grinding.

Surfaces of steel strips, sheets and/or other members of the construction which have to be assembled together by bolting shall first be smoothed so that a plane surface will be formed and seams will hardly be visible after assembling.

Sheets and strips shall be levelled. Shapes shall be straightened before assembling.

Cold bending will be allowed for non-bearing constructions which are not welded in the bending zone and only after approval of the Engineer. For all other constructions, warm bending is to be used.

Countersinking and enlarging of holes shall be executed with conical-shaped spiral-drills with at least 5 cutting edges. Boring machines with a fixed drilling line shall be used. Burr-sides and sharp edges caused by boring shall be removed.

### Welding

For welding of stainless steel pipes and fittings in generally the requirements stated in these Technical Requirements shall apply.

Welding shall be carried out in covered and well equipped workshops as far as possible. Where welding has to be carried out on Site the Contractor shall take adequate measures to protect welds.

All welding carried out during fabrication or erection shall be in accordance with the requirements of EN 1011 and as shown on the approved detail drawings. Details of the proposed weld procedures shall be submitted to the Engineerfor approval at the same time as the detail drawings. All connections shall be welded in such a manner as to make the finished connections neat and smooth in appearance and suitable for painting. All slag shall be removed and all sharp projections shall be round smooth.

Before welding is commenced either in the fabrication shop or on Site, weld procedure tests shall be carried out in accordance with EN 15614 where directed by the Engineer.

All welders employed either in the fabrication shop or on Site shall pass qualification tests relevant to the weld procedures in use in accordance with EN 287-1. Welders shall have satisfactory evidence of having been engaged in welding for at least 9 months in the preceding 12 month period. If the work of any welders employed on the Contract is unsatisfactory, the Contractor shall carry out such further welder qualification tests as are necessary to demonstrate that the welders are proficient.

Welds shall be subjected to non-destructive testing by processes which may include but shall not necessarily be limited to radiographic, ultrasonic, magnetic particle or dye penetrate methods, depending on the type of weld and its position in the structure. The standards of acceptance shall be as defined in EN 444, EN 583-3, EN 1289 and EN 1712, unless otherwise agreed with the Engineer. If any work shows defects or fails to comply with the requirements of the detailed drawings or Specification for any reason it shall be repaired or rejected, even though it may have been carried out by qualified welders using approved procedures.

All welding consumables (electrodes, wire, filler rods, flux, shielding gas and the like) shall comply with the requirements of EN 1011.

Weld electrodes for metal arc welding shall conform to EN 25184 and with the requirements of the appropriate weld procedure.

### Bolted Joints

Steel bolts and nuts for structural steelwork shall be high strength friction grip galvanized bolts conforming to ISO 887 or black bolts conforming to DIN 7990. Nuts shall conform to DIN 934. Washers shall conform to DIN 7989.

High strength friction grip bolts shall be used in conjunction with approved proprietary load indicating washers.

This article covers the assembly of structural joints using plain or galvanised high strength carbon steel bolts with suitable nuts and washers tightened to a high tension.

Bolts, nuts, and washers shall be protected from moisture during storage and shall show no signs of rust at the time of installation.

Plain bolts, nuts, and washers shall have a thin coat of lubricant at the time of installation.

Beeswax, stick paraffin or a lubricant approved by the Engineershall be applied to the threads of galvanised bolts just prior to installing the bolts.

Bolt, nut and washer (when required) combinations as installed shall be from the same rotational-capacity lot.

### Bolted Parts

The slope of surfaces of bolted parts in contact with the bolt head and nut shall not exceed 1:20 with respect to a plane normal to the bolt axis. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible material. Contact surfaces, including those adjacent to the bolt heads, nuts, or washers, shall be free of scale, dirt, burrs, oil, lacquer, loose rust, rust inhibitor, other foreign material, and other defects that would prevent solid seating of the parts. Paint shall be removed from the contact surface of bolted connections, on curved girder bridges and beam and girder splices.

### Installation

*Bolt Tensions*

Each fastener shall be tightened to provide at least the minimum bolt tension necessary. Fasteners shall be tightened by the turn-of-nut tightening method.

*Washers*

All fasteners shall have a hardened washer under the element (nut or bolt head) turned in tightening. Galvanised washers shall be used when galvanised nuts and bolts are required.

Where an outer face of the bolted parts has a slope of more than 1:20 with respect to a plane normal to the bolt axis, a smooth bevelled washer shall be used to compensate for the lack of parallelism.

*Load Indicating Bolts*

Tightening by use of a load indicating bolt system is permitted provided it can be demonstrated by an accurate direct measurement procedure that the bolt has been tightened properly. Tightening shall be by methods and procedures approved by the Engineer.

### Inspection

The Engineer shall be given full opportunity to observe installation of bolts to determine that the selected tightening procedure is properly used. The Engineer will determine that bolts are properly tightened and in the case of direct tension indicator bolts that the correct indication of tension has been achieved. Where the turn-of-nut method is used, each bolt will be inspected visually for the correct relationship between the match marks on the nut and the bolt shank. After bolts have been properly tightened, the end of the bolt shall be flush with or extended beyond the outer face of the nut.

Painting shall not begin in the area of tightened bolts until after bolt inspection is completed.

In addition to inspecting for match mark relationship with the turn-of-nut method, the following inspection procedure shall be used unless a more extensive or different inspection procedure is required by the plans or special provisions:

The Contractor in the presence of the Engineershall use an inspection wrench which shall be furnished by the Contractor and which shall be a properly calibrated torque wrench to check random selected sample bolts by applying, in the tightening direction with the inspection wrench, the job inspecting torque to 10% of the bolts, but not less than 2 bolts.

If no nut or bolt head is turned by this application of the job inspecting torque, the connection will be accepted as properly tightened. If any nut or bolt head is turned by the application of the job inspecting torque, this torque shall be applied to all bolts in the connection, and all bolts whose nut or head is turned by the job inspecting torque shall be tightened and reinspected, or alternatively, the Contractor shall retighten all the bolts in the connection and then resubmit the connection for the specified inspection.

### Painting

This Requirements cover the general requirements and standards of workmanship and the painting and protective coatings required to be carried out by the Contractor of the works, except where particularly redefined in individual specification clauses or as necessary due to a particularly corrosive local environment, the possible reaction of escaping chlorine on the works or on the structures or the reaction of chlorine residuals on phenolic paints (e.g. inside pipelines), harmful or toxic paint in contact with process liquids, or other special requirements, in which case the Contractor submit his own special specification along with his tender.

No alternative or substitute painting standard or specification will be accepted unless it is specifically required for the above stated reason. No painting or protective coating will be accepted by the Engineer unless it is at least to the standard and of the quality specified herein.

The Contractor shall be responsible for the complete cleaning, preparation, priming, painting and protection of the works carried out by him.

### Standards

Where no explicit instruction is given standards in the Specification or by the manufacturer concerning any particular aspect of the workmanship, materials or procedures in connection with anti-corrosion protective systems in the works for iron and steel structures, the relevant recommendations of the following standard or code of practice shall apply:

DIN 18364 Surface protection of steel structures

DIN 50900 Corrosion of metal

DIN 50928 Test of protective coating of iron and steel structures against corrosion

DIN 50976 Hot-dip galvanised coatings on iron and steel articles

DIN 8565+ 8567 Sprayed metal coatings

EN 2178 Measuring of Layer Thickness

EN 2360 Measuring of Layer Thickness

ISO 8501 Preparation of steel surfaces before application of paints and related products - Visual assessment of surface cleanliness -

ISO 8503 Surface roughness characteristics of blast-cleaned steel substrates

ISO 8504 Preparation of steel substrates before application of paints and related products - Surface preparation methods

### Uncoated Surfaces

The only surfaces of iron or steelwork or non-corrosion resistant materials, which are to be left, unprotected by paint or metals coating are:

* The internal surfaces of boxes or hollow sections which are of dimensions too small to permit access for painting either at the fabrication stage or for maintenance during the operation life of the steelwork and which are to be hermetically sealed by welding;
* Machine bright parts and bearing surfaces which shall be thoroughly cleaned, polished and protected from corrosion by painting with one coat of a mixture of white lead and tallow or other similar approved material before dispatch. The Contractor shall provide solvent for removing the treatment;
* Parts which are specified to include corrosion allowances instead of protective coatings.
* Bolts, nuts and washers and other demountable fastenings shall remain unpainted.
* Surfaces of iron or steel members, which are to have concrete cast against them. They shall be clean and free of deleterious matter and loose rust at the time of concreting. The paint protection system, to be applied to the permanently exposed faces of these members before the members are built in, shall be continued for 50 mm as marginal strip along the contact surface. No paint containing aluminium in metallic form shall be allowed to come into direct contact with the concrete.

### Local Conditions

All coatings shall be suitable for the long term protection of the plant under operational conditions at the site of installation. The Contractor's attention is specifically drawn to the extremes of temperature and humidity recorded in the region and he shall take into account possible abrasions, restricted ventilation, and the various potentially corrosive environments within the works buildings and structures.

### Colour Coding and Final Appearance

Pipework, tanks and ducting shall be colour coded by totally painting with an appropriate code colour to be submitted by the Contractor and to be approved by the Engineer.

The principal code colours shall be as follows:

* Water Blue
* Wastewater and sludge Green
* (Fuel) oil Brown
* Gas Yellow

The colour coding for other minor pipelines, etc., will be notified to the Contractor prior to the commencement of erection.

The Engineerwill choose the final colour scheme and decoration of the works.

### Coatings in Contact with Potable Water

Water in contact with the dried coatings shall not acquire an unpleasant taste or odour, shall not show the presence of dissolved phenol and shall not acquire more than 5 Hazen units of colour.

### Trial Areas and Sample Pieces

Prior to the commencement of the site, painting work designated area(s) or section(s) of the works shall be completely painted as a sample of the work and workmanship to be carried out. The area(s) or section(s) shall include complete samples of all the major painting required in the works.

The area(s) shall be offered for review by the Engineer and shall, upon approval, be then preserved as a reference standard for the work.

No extra payment will be made for carrying out such protection or decoration in advance of the general work, or for the removal and repetition or improvement of the work if required by the Engineer in order to achieve the specified standard.

### Precautions

All surface fittings, ironmongery, etc., except hinges shall be removed before painting and refixed on completion. They shall be entirely free of any droppings, paint smears and blemishes. Labels, pump and other machinery name plates, data plates, markings, etc., shall not be overpainted but carefully preserved by removal and replace­ment or by masking.

The Contractor shall pay particular attention to the toxicity, inflammability and the explosive dangers related to the storage and application of the systems and shall take all precautions necessary to the satisfaction of the Engineer to protect his operatives, the public and other site personnel.

### Equipment

The equipment used for spray application of paint shall be suitable for the intended purpose, shall be capable of properly atomising the paint to be applied, and shall be equipped with suitable pressure regulators and gauges. The air caps, nozzles, and needles shall be those recommended by the manufacturer of the equipment for the material being sprayed. The equipment shall be kept in satisfactory condition to permit proper paint application.

Traps or separators shall be provided to remove oil and water from the compressed air. These traps or separators shall be of adequate size and shall be drained periodically during operations. The air from the spray gun impinging against the surface shall show no water or oil.

An agitated spray pot shall be used to keep the paint well mixed.

Airbrushes, brushes, tools and equipment shall be kept in a neat and clean condition.

### Paint

All coatings, primers, compatible and undercoats and finishing paints of any one complete protective system shall be compatible with each other. As far as is practicable, materials, forming any one protective and/or decorative system used in the permanent works, shall be obtained from one manufacturer.

Painting shall consist of painting with at least two layers of paint (primer and finish paint). The Contractor shall submit to the Engineer paint documentation for approval. No painting shall be performed without approval of the Engineer.

Paints shall be polyamide-adduct cured, high solids, hi-build epoxy paint, rust inhibitive.

Total thickness of all layers shall be at minimum 300 μm.

All paint shall be "new" and "fresh" and obtained from approved manufacturer(s).

All paint shall be supplied in sealed containers bearing the following information in addition to any statutory requirements:

* Manufacturer’s name, initials or trade mark;
* Whether priming, undercoat or finishing coat;
* Whether for interior or external use;
* The colour reference number;
* The method of application (e.g. brush);
* The batch number and date of manufacture of re-test
* The shelf life of the contents.
* Containers for materials other than paints shall bear as much of the above information as appropriate.

Paint, thinners, etc., shall be stored in sealed containers in a lock-up store at a temperature of not less than 4°C and not more than 27°C. Any special storage conditions for the paint recommended by the manufacturer shall be observed.

Paint shall be supplied from the Contractor's paint store to the painters ready for application. Any addition of thinners shall be made in the store under supervision and up to the limit detailed on the appropriate manufacturer’s paint data sheet for the particular method and conditions of applications concerned.

### Preparation

All contaminates such as soil, concrete, weld splatter, grease, or any other deleterious material shall be cleaned from the steel or shop coated surfaces before any painting operations begin. Harsh environments may necessitate re-cleaning during or between paint applications.

Steel surfaces to be coated shall be cleaned by means of shot blasting according to ISO 8504 after welding has or bolted connections have been finished unless otherwise specified.

If necessary, all steel parts shall be degreased before shot blasting. All surfaces shall be completely dry during and after the blast operation. The finished surface shall uniformly expose the bare metal and shall present an etched, but not polished appearance. Not more than 5% of the surface may exhibit very light shadows, light streaks or slight, light residues of paint or coating. The grade of derusting shall comply with ISO 8501-1 SA 2½. Abrasives shall be restricted to reusable iron or steel (grit and shot) or copper slag. The type and grades of abrasive shall be selected in accordance with the appropriate standard:

* Aluminium oxide (corundum, vasil grit)
* Copper slag
* Steel grit with a maximum grain diameter of 0.7 mm
* A mixture of steel grit as mentioned above and steel wire cutting in a ratio of 50 to 50.

Those parts of the construction which are inaccessible for shot blasting after welding has or bolted connections have been finished shall be cleaned by using power actuated wire brushes and immediately painted with a coat of weld primer or a similar product.

If necessary, loose mill scales which remain after shot blasting shall be removed and any uneven surfaces, pits, etc. shall be ground before the application of the coating. Blast-cleaned surfaces shall be brushed, blown or vacuum cleaned to remove any trace of blast products prior to coating.

Within 4 hours of completion of surface preparation, and before surface re-rusting occurs, a coating of primer shall be applied to avoid deterioration of the prepared base metal. No contamination shall be permitted to occur between blast cleaning and primer coating.

The Contractor shall supply and operate such dehumidification equipment as may be necessary to preserve blast cleaned surfaces in a pristine condition until they can be coated and/or to provide the curing conditions necessary for such coats.

### Painting Conditions

Ambient air temperature shall be at least 3°C higher than its’ dew point. Ambient air relative humidity shall not exceed 85%, ambient air temperature shall be in the range 10 - 30°C.

Painting shall not be carried out in the vicinity of other operations, which might cause dust.

Coatings shall be applied after fabrication of the items is completed, including all punching, welding, drilling, grinding, screw tapping and cutting, and after the removal of surface defects. Tapped holes shall be blanked off before the metal coating is applied.

### Workmanship

Unless otherwise permitted by the Engineer, all paint shall be applied by spraying, except the strip coat shall be applied by brush and minor repairs to the primer may be made by brush.

The applicator shall have a current copy of the paint manufacturer's application instructions, along with Material Safety Data Sheets for each paint and shall furnish copies to the Engineer. Unless otherwise required herein, application shall be in accordance with the manufacturer's instructions.

Application of the paint shall not be started until the paint materials have been approved by the Engineer.

Painting shall be performed in a neat and workmanlike manner. Paint shall be applied in a uniform layer, with overlapping at the edge of the spray pattern. The spray pattern shall be adjusted so that the paint is deposited uniformly. Application shall be such as to provide a tight film of the specified thickness, well bonded to the metal or previously applied paint, and free of laps, streaks, sags, or other defects.

Each coat of paint shall be in a proper state of cure or dryness before application of the succeeding coat.

Each successive coat shall preferably be of slightly different colour or shade to facilitate inspection. The Engineer may apply his own identification markings on undercoats to ensure full compliance with the Specification.

### Paint Thickness and Measurement

Total thickness of all layers shall be at minimum 300 μm.

The Contractor shall provide and maintain, during manufacture and on site, gauges and measuring equipment of an approved type to ensure that the specified film thickness is achieved, paint holidays are avoided, and adhesion is to the satisfaction of the Engineer.

Wet film thickness gauges shall be provided to and used by each painter to check the rate of paint application.

The thickness of the built-up dry film after each paint coat applied to steel or other magnetic surfaces shall be measured systematically with a dry film thickness gauge.

The Contractor shall adopt holiday detection on surfaces and shall use a suitable method of detecting pinholes in the coating system after trials on test plates, which shall be notified in advance to the Engineer.

The sweep voltage on high voltage DC equipment shall not exceed half the voltage required to spark through the complete paint system specified.

Gauges, instruments and meters shall be maintained in an accurate working condition and shall be made available to the Engineer for checking when requested.

The following instruments, with the manufacturer’s operating instructions, shall be provided, maintained and used by the Contractor's inspector. In addition, under the Contract a separate set shall be provided and maintained for the Engineer’s sole use for the duration of the Contract:

* 1 adhesion tester, cover 0 to 280 kg/cm2;
* 1 DC high voltage holiday detector, 20 kV, with rechargeable batteries;
* 1 paint inspection gauge, 0 to 500 μm;
* "wet-check" moisture meters with suitable concrete and timber scales;
* 1 dry film thickness gauge, 0 to 500 μm;
* Wet film gauges, up to 500 μm;
* 1 steel temperature gauge, up to 50°C;
* 1 air humidity gauge;
* 1 air Thermometer (maximum and minimum);
* Surface profile gauge, up to 150 μm.

Daily checks shall be carried out and recorded on site

### Tolerances

References in the Specification to dry film thickness (DFT) shall mean the minimum dry film thickness measured with a suitable instrument, either of individual coats, or the total system, as specified in μm. The maximum permissible coat tolerance shall be +15%, -0% over the DFT.

Adhesion tests shall carried out on the cured coating using the test equipment supplied under the Contract in accordance with the best practice. The resulting test specimen shall show no indication of poor adhesion to the substratum, residual laitance or intercoat adhesion weakness.

### Painting and Protection of Bolted Connections

Joint areas of bolted connections shall be masked to maintain the surfaces free from any paint applied prior to making the connections. Masking shall be removed before erection.

After installation and after all bolts have been tightened, the area of the connection shall be cleaned to remove all dirt, dust, oil or other contaminant. Particular care shall be taken to ensure that all traces of oil and grease are removed from bolts, nuts and washers.

Bolts, nuts and washers and any exposed at bolted connections shall also be primed as specified, particular care being taken to ensure that any crevices are fully sealed.

The remaining coats of the paint system shall then be applied.

Following painting and where the bolted connections are in an area to be backfilled (pipe trench flanges, etc.) the bolts, nuts and washers and the entire joint assembly shall be carefully packed with an approved purpose made water proof protective paste (non solvent) and finally wrapped with an approved protective paste impregnated tape to completely encase the assembly. Pipe joint protection shall continue along the length of the barrel for a distance of 20 cm.

### Copper and Brass

Copper pipes and brass fittings shall be painted where they are located in aggressive locations, or to colour code the function.

### Repair of Damaged Work

Unless specified elsewhere, areas of paint on steelwork, which have been damaged, shall be cleaned to sound material and the edges of the undamaged paint smoothed with sand-paper to a gentle bevel.

The specified paint system shall then be applied in accordance with manufacturer’s instructions to bring the damaged area up to the same state of protection as the sur­rounding paintwork, with each coat of new paint overlapping the corresponding existing coat of paint by at last 50 mm.

### Waste

The Contractor shall provide on-site suitable moveable receptacles into which are to be placed all the liquid, slops, washings, etc. All solid refuse or inflammable residues shall be removed from site or carefully burned. No refuse shall be deposited on any soil or disposed down any permanent sanitary fittings, sinks or drains. The Contractor shall immediately clean up any unauthorised deposition and remove from the site any employee found to be responsible.

### Galvanising

Steel or wrought iron shall be hot-dip galvanised as required by the Engineer. The galvanising shall be carried out after all fabrication has been completed and approved by the Engineer. Metal components to be hot-dip galvanised shall not be shot blasted unless.

The articles shall be thoroughly cleaned and pickled in dilute sulphuric acid or hydrochloric acid followed by rinsing in water and pickling in phosphoric acid. They shall be thoroughly washed, stoved and dipped in molten zinc and brushed so that the whole of the metal shall be evenly covered. The edges shall be clean and surfaces smooth and bright. The layer thickness shall be 80 μm minimum. Generally, hot-dip galvanising shall comply with the requirements as specified in DIN 50976.

Galvanised surfaces that are abraded or damaged shall be repaired by thoroughly wire brushing the damaged area and removing all loose and cracked coating, after which the cleaned area shall be given 2 coats of inorganic zinc rich epoxy paint.

## Delivery and Assembly

### Test Assemblies

If required by the Engineer, all items that shall be installed for the Works, shall be temporarily assembled at the place of manufacture for inspection and, if considered necessary, they shall be tested before delivery. The cost of such erection and testing shall be included in the rates. The Contractor shall give to the Engineer written notice of the date on which parts of the structures will be ready for inspection and testing.

### Packing and Marking

All components of the steel structures shall be clearly marked in the workshop or at the Site(s), in accordance with the working drawings.

The Contractor shall mark and, as necessary, protect all parts for delivery, unloading, handling, storage in the open and subsequent transport to Site. Attention shall be given to the pro­tection of parts which are liable to deterioration in the climatic conditions prevailing at Site. No damage to equipment shall result from normal handling or prolonged storage in the open. Small parts shall be boxed and suitably marked on the outside. Larger parts shall be protected as necessary and shall be suitably marked and listed. Each crate, box and bundle shall also be provided with an identification of the weight in kilograms or tons and a mark for the top side. Lists of contents of crates, boxes and bundles shall be supplied and shall be han­ded over to the Engineeron delivery of each consignment.

Attention shall be given to the method of marking sub-assemblies and other components to as­sist in identifying them at Site. The method of marking employed shall enable any particular components or sub-assembly to be easily identified from the Contractor's drawings and also from the Transport Specifications. Where practic­able, components for each individual site shall be packed separately so that all equipment required for each site may be easily separated and transported to each site. The Contractor shall send a written notice to the Engineerfor inspection of the packings and marking before transportation to the Site.

### Storage at Site

All steel structures or components shall be stored in such a way as to provide a minimum clea­rance from the ground of at least 150 mm. Fixing materials and associated parts shall be stored in lockable sheds. These sheds shall be provided with wooden floors. Areas for storage and/or assemblage, including vicinity, shall be cleared of weeds and/or rubbish. Care shall be taken in storing bolts; nuts etc. at Site to ensure that threads do not become damaged and are kept perfectly clean.

## Particular Steelworks

### Manhole and Access Covers and Frames

Manhole and access covers and frames shall have minimum openings of diameter 800 mm or of 800 x 800 mm and shall be capable of taking a load of 40 t (400 kN) as per Class D of EN 124.

Manhole covers and frame material shall be spheroid graphite cast iron in accordance with EN 1563.

All manhole and access covers and frames shall incorporate a suitably secured gas tight GRP or ABS sealing plate to the approval of the Engineer. [new]

A heavy grease seal is to be formed between the cover and frame to prevent the ingress of sand and water.

Manholes and access covers located in roads shall have non-rocking covers.

Keyways in manhole covers shall be closed.

### Surface Boxes

Surface boxes shall be manufactured from cast iron, complying with DIN 4055, 4056, 4057, 4058 or 4059. The lid shall be chained to the frame.

Surface boxes and access covers located in roads shall have non-rocking covers.

### Open Steel Flooring

Open steel flooring and gratings shall generally comply with DIN 24537 except where otherwise specified hereinafter. Such flooring and gratings shall be of rectangular mesh and non-slip and shall be mild steel. Mild steel flooring and gratings shall be galvanised as specified herein after the fabrication is completed in­cluding all necessary cut outs where possible.

Flooring and grat­ings shall be removable and set flush in frames of the same materials.

Frames shall be provided with lugs for building in.

Flooring shall be provided to span between the supporting members. Where necessary intermediate structural steel support members shall be provided and fixed. Flooring panels shall be provided in sizes suitable for removal by one man with the appropriate cut outs to accommodate equipment pas­sing through the flooring. Such removable sections shall be tightly screwed to the framework with a single access panel 900 mm by 900 mm hinged and provided with locking arrangement. A three lever brass padlock of size approved by the Engineershall be supplied complete with keys.

Both the load bearing and transverse bars in rectangular flooring panels shall be positioned symmetrically around the centre lines of the panels in both directions so that when the panels are fixed in extensive areas or in long runs the bars of all panels are in line. All floor panels shall withstand a minimum intensity of distri­buted load of 5.0 kN/m², with a deflection not exceeding 0.5% of the span or 10 mm whichever is the lesser.

### Chequer Plates

Chequer plating shall generally comply with DIN 59220 except where otherwise specified hereinafter.

Chequer plating if shown on the Drawings or ordered by the Engineer shall be complete with cut-outs and in sizes suitable for removal by two men. It shall be of mild steel and of sufficient thickness to carry a loading of 5.0 kN/m² but never less than 5 mm thick. The thickness of chequer plating shall be measured excluding the pattern which shall be of a non-slip type. Flooring shall be provided in sizes suitable for lifting and removal by one man and with the appropriate cut-outs to permit its removal without disturbing or dismantling spindles, supporting brackets, cables or pipework. Intermediate supporting members shall be provided and fixed.

Chequer plating over openings in concrete or brickwork shall be set flush in mild steel frames provided with lugs for building in. Chequer plating and frames shall be galvanised in accordance with the Specification. Chequer plate flooring shall be secured to its frame by stainless steel countersunk set screws. Lifting keys shall be supplied at each location.

### Steel Staircases

Stairways shall be designed for a loading of 5.0 kN/m² of plan area of the stairway. Steel stairways shall be provided with tubular hand railing, stringers of cross section suitable for the span and loading and treads of open mesh flooring or chequer plating. Except where specified otherwise, the rise between treads shall be uniform and between 150 mm and 175 mm. Stairways in the same area of the works and in similar locations shall have the same angle and height of rise between treads.

The width of the treads shall be between 250 mm and 300 mm. The width of the stairways shall not be less than 750 mm.

The stringer shall be mounted by means of angle brackets with slotted holes for adjustment of line and level.

The specifications for stairways in leachate and chemicals tanks and treated leachate and wastewater manholes are described in these Employer’s Requirements, Section 3 General Specifications for Mechanical Works.

### Step Irons

Step irons shall comply with DIN 1211-2.

### Steel Ladders

Steel ladders shall generally comply with DIN 3620 expect where otherwise specified. Ladders shall be fabricated of hot dip galvanised steel. The stringers shall be sized to suit the height of the ladder and the interval of the stringer supports. The stringers shall be radiuses over the top where they shall be not less than 600 mm apart.

The bottom ends of the stringers shall not be designed for floor fixing, but shall terminate at wall fixing supports at least 150 mm above the floor. All edges of stringers shall be ground smooth to remove burrs and sharp edges.

Rungs shall be 25 mm diameter solid equally spaced at 300 mm centres, shouldered at each end and securely riveted into countersunk holes. Rungs shall be not less than 225 mm from the wall.

All ladders rising more than 2.50 m from lower platform or ground level to the top rung shall have safety cages which shall be constructed of three flat verticals supported by flat hoops with a diameter of 750 mm. The hoops shall be approximately 700 mm centres and the first hoop shall be 2.4 m above ground or platform level.

Where hoops cannot be installed, safety systems against falling down according to EN 353 (personal safety gear against falling - travelling devices with a fixed guidance) must be installed.

Where the rise exceeds 6.2 m an intermediate landing shall be provided.

Vertical ladders shall be installed alternating left hand/right hand side to landings.

### Handrail

Handrail shall consist of hot-dip galvanised steel according to DIN 24533 with handrails and standards designed to withstand a horizontal force at handrail level of 740 N/m run. The deflection of rails shall not exceed 1% of their span between standards and the deflection of standards shall not exceed 1% of their height.

Standards and handrails shall be not less than 32 mm in diameter.

Horizontal handrails shall be 1,100 mm high with an intermediate rail 550 mm high. Handrail height shall be measured vertically from finished floor level to the handrail centreline.

Sloping handrails shall be as specified for horizontal handrails but with the top rail 900 mm vertically above the line of pitch and stanchions vertical and spaced at not more than 1.5 m measured parallel to the line of pitch.

Horizontal mounting flanges shall be drilled for not less than three bolts with two bolts on a line parallel to and on the walkway side of the line of the handrail. Vertical mounting flanges shall be drilled for not less than two bolts the line through the bolts being vertical. Fittings shall be screwed or secured with grub screws. The standards shall be set at not more than 1.5 m centres. When provided in sections handrails shall be gained together with purpose made fittings secured by screws or grub screws.

Ladders and other openings shall be closed with two galvanised mild steel hanging chains which shall be secured at one end and detachable at the other.

Bolts, nuts and washers shall be hot-dip galvanised.

The Contractor shall ensure that, unless specified to the contrary, all handrails shall be of uniform appearance and manufacture.

Detailed Drawings of handrails shall be submitted by the Contractor for the approval of the Engineer.

## Steel Tanks

### Standards

The Contractor shall furnish shop drawings for approval to the Engineer of each tank and all items and accessories in accordance with the Technical Requirements. No tank manufacturing or installation shall begin without written approval of the Engineer.

The materials shall comply with standards, but shall not be limited by the following:

AWWA D 100 Welded steel tanks for water storage

AWWA D 102 Painting steel water-storage tanks

API 620 Recommended rules for design and construction of large, welded, low-pressure storage tanks

ANSI/API 650 Welded steel tanks for oil storage

ASME Boiler and pressure vessel code

DIN 6608 Underground mineral oil horizontal storage steel tanks

DIN 6616 Aboveground mineral oil horizontal storage steel tanks

DIN 6617 Partly aboveground mineral oil horizontal storage steel tanks

DIN 6618 Aboveground mineral oil vertical storage steel tanks

DIN 6619 Partly aboveground mineral oil vertical storage steel tanks

EN 286 Simple unfired pressure vessels designed to contain air or nitrogen

prEN 764 Pressure equipment: terminology

prEN 13445 Unfired pressure vessels

prEN 13831 Closed expansion vessels with built-in diaphragm for installation in water systems

### General

All tanks shall be fabricated by reputable manufacturers, experienced in the design and fabrication of the specific tanks, and familiar with all applicable local regulations, codes, fire and safety orders.

The Contractor shall install steel tanks and appurtenances in accordance with the requirements of the manufacturer, approved shop drawings, applicable codes, and the Contract Documents.

Where not otherwise specified the Contractor shall provide corrosion-resistant materials suitable for long-term service.

All factory-made pressure tanks shall be tested as listed below, test certificates shall be submitted to the Engineer. No factory-made pressure tank shall be delivered to site before written approval of the Engineer:

* X-ray inspection,
* Ultrasonic thickness check,
* Hydraulic test,
* Penetration dye test,
* Heat treatment,
* Chemical analysis and spectral analysis,
* Tensile, compression, bending and hardness tests

Each tank shall bear a stainless steel nameplate which contains the design and fabrication information required by the reference standard. Each nameplate shall bear the applicable code symbol.

In assembly and during welding the component parts shall be adequately clamped, supported and restrained to minimise distortion and for control of dimensions. Weld reinforcement shall be as specified by the reference standards, and excessive reinforcement shall be ground down to within the requirements, and as required to install the lining systems. Upon completion of welding all weld splatter, flux, slag, and burrs left by attachments shall be removed. Welds shall be repaired to produce a workmanlike appearance, with uniform contours and dimensions. All external corners and edges shall be ground to a 2 mm radius. All internal corners and edges shall be ground to a 3 mm radius, or a greater radius if required by the lining system.

Flat bottom tanks shall have butt-welded bottoms, with a steel thickness of at least 10 mm.

All openings 100 mm and greater in nominal diameter shall be reinforced.

Tank shell joints shall have complete joint penetration and fusion, and shall be welded from both sides. Before the second side is welded the joint shall be arc-gouged to sound metal.

For flat bottom tanks, the corner joint shall be tested after the inside fillet weld is complete by applying a weld-compatible penetrating oil to the outside of the joint and observing the inside fillet weld for indications of oil penetration.

All shell attachments for pipe supports, tank gauges, instruments and other items shall be welded to the tank shell before application of the tank lining.

After fabrication but prior to application of linings each tank shall be tested in accordance with the reference standards.

Unless otherwise specified, the minimum thickness for steel plates used for shells, roofs, or heads shall be 6 mm.

Tank details shall be designed to avoid joints that will promote corrosion (up-directed welds etc.), pockets that will accumulate rainwater or chemicals, and attachments to the shell which result in excessive localised stresses due to welding supports or imposed loads.

Access openings shall be flanged, and, unless otherwise specified, have a nominal diameter of at least 60 cm. The cover plate and flange shall each have a net thickness, after machining, of at least 12 mm.

All fittings shall be flanged.

Anchor bolts shall have a nominal diameter of at least 25 mm, unless otherwise shown, and shall be anchored into concrete foundations using methods designed to transfer the full ultimate strength of the anchor bolt to the concrete foundation. Anchor bolts shall be attached to the tank by use of anchor bolt chairs or rings, as required, and such chairs or rings shall be designed to transfer the full ultimate strength of the bolt, or 150% of the calculated load, whichever is less, to the tank shell.

Unless otherwise specified, the exterior buried surfaces of all tanks shall be sandblasted in accordance with these ER, and receive one coat of coal tar primer followed by a finish coat of hot-applied coal tar enamel. Thickness of the enamel coating shall be 2 mm ±0.5 mm. The time between application of the primer and enamel shall not exceed 5 days. Materials and application shall conform in general to the requirements of AWWA D 102.

Unless otherwise specified, the unburied exterior surfaces of all tanks shall be painted as specified in these ER.

Unless otherwise specified, all unfired pressure tanks shall be fabricated for a pressure rating of at least 50% above the maximum expected operating pressure.

Where required by state or local authorities, buried tanks containing oil, chemicals, or harmful waste products, shall be of the double-wall containment type, including pressure pipes to and from such tanks, with approved detection devices per local codes.

### Folded Joint Tanks

Fold joints shall be completely water and gas-tight and shall provide on the inside of the tank a surface free from grooves and edges.

### Spiral Band Tanks with Folded Joints

This section covers tanks made from endless spiral band with folded joints. The band shall be prefabricated at the Manufacturer and cut to size in the factory and rolled into one or more coils. The type and strength of the material shall depend on the respective static requirements.

Erection shall be accomplished by special machines unreel from the coil, to bend the folds and to fold and to assembly.

The bending machine shall process the upper and lower edges of the band into an open profile. The profiled tape is fed inside the assembly ring to form a circular shape until after one or more rotations it is taken up by the folding machine. The band being continually unreeled and taken up, the profiled and neighbouring bands run together into the folding machine where they are joined into a sealed fold.

Growing from the bottom, the upper edge of the tank shall be cut to size after the first 2 to 3 rotations. As required roof supports, cover and appurtenances shall be erected at this stage of the work as well as coating of the already erected parts.

In case the requirements for the inner lining of the tank are higher than for the outer lining, composite steel materials may be used. Stainless steel layer shall be galvanically insulated from mild or hot-dip galvanised steel layer by an endless acrylic tape.

The folds shall be sealed with an appropriate sealant bands (EPDM, synthetic rubber), laid between the rebates and folded together with the rebates in such way that the sealant band is clamped between the folded rebates.

All bolts, nuts, washers shall be of stainless steel.

##### Glass-fused-to-steel Panel Tank with Bolted Joints

This section covers storage tank made of sectional steel panels with glass molecularly bound (fused) to the steel surface.

Panels shall be transported to the site only flat packed. The glass-fused-to-steel panels shall be ready for bolting together and complete with any special cut-outs for nozzles and/or manways or other appurtenances as required.

Panels shall be aligned and adjusted before final bolting. Vertical bracing profiles of sufficient strength and in a sufficient distance shall be bolted to the panels. The bracing profiles shall be anchored to the concrete slab to provide dimensional stability. Bracing profiles shall be hot dip galvanised and painted according to ER.

The bottom angle shall be levelled on shims and secured to the concrete base with anchor bolts. The rebate shall then be filled with concrete. A perimeter seal (mastic, EPDM, synthetic rubber) shall be laid between rebate and concrete base to ensure a water tight interface.

The sealant (mastic) shall be applied to the overlap sheet surface and shall be allowed to dry and cure in order to form an adhesive bond with the glass on the panel. The used mastic shall be permanently flexible to join the tank movements.

All bolts, nuts, washers shall be of stainless steel and shall be additionally plastic-capped (shrink Teflon) to provide corrosion protection in the process environment. Mastic squeezed out between the panels and the bolt head shall not be removed as it seals the shank and protects it from contact with process fluids.

### Steel Protection Covers for Membrane Gas Tanks

Steel protection covers for membrane gas tanks may erected from prefabricated vertically or horizontally corrugated steel panels factory-coated according to Sub-clause 17.6. (Painting).

Panels shall be aligned and adjusted before final bolting to the vertical bracing profiles of sufficient strength and in a sufficient distance. The bracing profiles shall have a welded head plate to fix the anchors bolts to the concrete slab to provide dimensional stability. Bracing profiles shall be hot dip galvanised and coated according to Sub-clause 17.6. (Painting).

The bracing profiles shall be levelled on Teflon shims. The void between the lowest panel and the concrete slab shall then be filled with concrete.

All bolts, nuts, washers shall be of stainless steel.

### Membrane Surge Tanks

Surge tanks shall be of the size shown and shall be designed for the needed working pressure.

Surge tanks shall be designed, fabricated and tested in accordance with the current standards and shall include fittings as required.

The tank shall be equipped with the necessary appurtenances (float valves for make-up water, drain connection, water level gauges, pump suction threaded nozzles, 3-way valves with strainer, condensate returns, vents, flanged maintenance holes, water level cut-off float switches, etc.).

Interior surfaces of the tanks shall be sandblasted as per Sub-clause 17.6. (Painting) and factory coated with a total 1 mm dry film thick coating.

The membrane shall be gas and watertight and made of butyl synthetic rubber. The membrane shall be exchangeable.

The Contractor shall fully charge the surge tank with compressed air or N2-gas in accordance with the manufacturer's instructions prior to testing the system, and shall make the necessary final adjustment in pressure prior to acceptance by the Engineer.

### LPG Storage Tanks

LPG storage tanks shall be of the sizes shown and shall be fabricated in accordance with applicable State and local requirements. All required appurtenances, safety devices, shut-off valve, liquid level gauge, hood, supports and lifting eyes shall be provided. All valves and fittings shall be suitable for 1.6 MPa working pressure and all LPG piping shall be black steel pipe, in accordance with all applicable codes. Each tank shall be set horizontally on not less than two reinforced concrete supports, with anchor bolts. All tank details, safety devices, warning signs, and fire prevention systems shall be to the satisfaction of the local fire protection authorities.

### Gasoline Storage Tanks

Gasoline storage tanks shall meet all applicable local requirements.

### Fuel Oil Storage Tanks

Fuel oil storage tanks shall be of the sizes shown. General design and plate thickness shall be conform local requirements. All necessary accessories shall be provided as required.

Inside surfaces of the tanks shall be pickled or sandblasted to remove all mill scale, thoroughly cleaned of all dust and foreign matter and lightly coated with oil. All tank openings shall be sealed prior to shipment to the site.

### Lube Oil Storage Tanks

Lube oil storage tanks shall be of the sizes shown. Plate thickness shall be 6 mm minimum unless otherwise shown. All necessary accessories shall be provided as required.

Inside surfaces of the tank shall be pickled or sand-blasted to remove all mill scale, thoroughly cleaned of all dust and foreign matter and lightly coated with oil. All tank openings shall be sealed prior to shipment to the site. Any areas of the coating which become damaged during handling and installation of the tank shall be repaired to the satisfaction of the Engineer.

### Steel Chemical Tanks

General: Steel chemical tanks shall be of all-welded steel construction. They shall be designed for static fluid head and atmospheric pressure, and be of the sizes shown. Plate thickness shall be 6 mm minimum unless otherwise shown. Tanks shall be fabricated and certified in accordance with the respective standard. Nozzles shall have reinforcing pads where necessary for structural strength, and all nozzles, maintenance holes, couplings, brackets, ladders and other appurtenances shall be as shown.

After fabrication, the tanks shall be hydrostatically tested by filling them with water. Any leaks disclosed shall be repaired by welding.

Interior of steel chemical tanks shall be factory-prepared and lined in accordance with the following requirements:

1. General: The interior of all chemical tanks (excluding caustic tanks), including tank nozzles and maintenance holes, shall be lined with polyvinyl chloride sheet or neoprene sheet as required or shown in the tank schedule, secured to the metal surface with adhesive. The sheet material shall have a minimum thickness 2,5 mm. Nozzle necks and flange faces also shall be lined. Primers, adhesives, activators, accelerators, or other necessary materials and their methods of application shall be as recommended by the manufacturer of the sheet material.
2. The metal surface shall be sandblasted as per this ER to remove all mill scale, rust, grease, or other surface impurities. All weld splatter shall be removed and all rough welds ground smooth. After blasting, all dust shall be removed by brush or vacuum.
3. Primer shall be applied as soon as possible after blasting. An unprimed blasted surface shall not be left overnight. Immediately before applying primer, the metal surface shall be dusted thoroughly with a brush or clean cloth to remove all foreign matter. Primer shall be applied by brush, working it thoroughly into the surface to obtain a smooth and even coat with no bare spots.
4. Adhesive: Adhesive shall be applied to the primed metal surface and to the sheet surface by brush or roller to a uniform thickness with no sags or thin areas. The applied adhesive shall be protected from sunlight, foreign matter, or physical damage during the drying and curing time. For neoprene application, adhesive shall be applied to the primed metal surface and to the neoprene sheet at the same time; and the 2 surfaces shall be bonded together that same day.
5. Activator shall be applied by brush to the PVC adhesive on both the metal and sheet surfaces. It shall not be applied to a larger area than can be covered by sheet in a 20-minute period. Sufficient time (approximately 5 to 10 minutes) shall be allowed after applying the activator for the adhesive to become tacky before bonding the PVC sheet.
6. After the preparation described above, the PVC sheet shall be placed and bonded as follows: the edge of the sheet shall be placed in position and pressed firmly, holding the remainder of sheet away from the adhesive. When the edge is bonded, the remainder of the sheet shall be rolled into position, carefully forcing out air pockets at bond edge. After sheet is affixed, it shall be rubbed with a soft cloth to assure uniform bond.
7. Neoprene sheet shall be placed and bonded as follows: sheet shall be covered with a clean dry cloth and placed in position. Using cloth will prevent adhesion of the sheet to the metal while it is being fitted into place. When sheet is in position, the cloth shall be folded back and turned down. An edge of the sheet shall be forced into place with a roller to initiate bond. Cloth shall be pulled ahead of rolling operation until sheet is completely bonded. Care shall be exercised in rolling to assure that no air is trapped under the sheet.
8. Adjoining PVC sheets shall be installed by butting them tight at the edges and by welding a strip of PVC sheet over the joint. Welding shall be done with a hot-air welding gun. Before welding, sheets shall be thoroughly cleaned and wiped. Neoprene sheets shall be similarly formed, and the neoprene strip shall be bonded over the joint with adhesive.

### Condensate Tanks

General: Condensate tanks shall be of the horizontal type, [skid mounted], complete with boiler feed pumps, valves, piping, prewired pump controls and all appurtenances as shown.

Tanks shall be of the size shown and shall be designed suitable for hot water and steam, vented to atmosphere. Tanks shall have a minimum shell thickness of 5 mm.

Interior surfaces of this tank shall be sand blasted as per Sub-clause 17.6.8.10 and factory-coated with a total 0.5 mm dry film thick coating applied in 2 or more coats and according to this ER.

The tank shall be equipped with the necessary appurtenances (float valves for make-up water, drain connection, water level gauges, pump suction threaded nozzles, 3-way valves with strainer, condensate returns, vents, flanged maintenance holes, water level cut-off float switches.

### Expansion Tanks

Expansion tanks shall be horizontal, welded steel tanks, constructed in accordance with the current Standards.

The tank shall be equipped with saddles, supports, gauge glass assembly with armoured heavy duty protection, ball checks, test valves, drain valve, and drain piping.

After installation, the tank shall be insulated.

## Structural Steelwork

The permissible design stresses for materials, bolts, rivets, etc shall be in accordance with EN standards.

Rolled structural steel sections shall be mild steel complying with the requirements of EN 10025 and EN 10029. The dimensions, tolerances and properties of the structural sections shall conform to EN 10034 or EN 10067

Structures and components, such as required for ladders, hoppers etc shall be shop fabricated so as to form sub-assemblies of the largest practical size suitable for transportation, handling and erection.

The Contractor shall submit drawings and calculations of his proposals for structural steelwork prefabricated building frames in duplicate for the Engineer’s approval, 21 days before commencing fabrication.

The coating systems shall be as given in the Employer’s Requirements, Section 3. General Specifications for Mechanical Works.

# Concrete Pile Foundations

## Standards

In addition to the standards as listed the following standards shall apply:

ASTM D 1143 Piles under static axial compressive load

ASTM D 3689 Test method for individual piles under static axial tensile load

ASTM D 3966 Test method for piles under lateral loads

ASTM D 4945 Test method of high strain dynamic testing on piles

ASTM D 5882 Test method of low strain dynamic testing on piles

DIN 4014 Standard reinforced concrete bored piles

DIN 4026 Standard reinforced concrete displacement piles

EN 1536 Bored piles

ENV 1997 Eurocode 7: geotechnical design

prEN 12699 Displacement piles

## General

Pile foundation may be necessary for supporting structures where the subsoil is considered to have insufficient bearing capacity. The Contractor shall carry out detailed design of these structures in accordance with the Contract Conditions and Technical Requirements and shall determine the type of foundation required, the number of piles and their working loads and the optimum arrangement of piles required for supporting the structures.

Excavation, concrete steel reinforcement and steel casing where applicable shall conform to the relevant Clauses of the ER.

At least 21 days before the Contractor intends to commence piling work on the site the Contractor shall submit for the Engineer’s approval full details of his proposed piling system including the type and dimensions of piles, reinforcement details and full details and full design and driving calculations. The details to be submitted shall include the Contractor’s proposals for equipment, temporary works and construction methods.

No work on piling shall commence on the site until the Engineer’s approval to the Contractor’s proposal has been received.

## Types of Piles

Bearing piles shall be driven reinforced concrete, precast concrete or cast in-situ concrete piles. All concrete shall be in sulphate resisting cement according to these ER.

## Design of Piles

Piles shall be generally designed in accordance with appropriate DIN standard and the materials and work shall conform to the requirements of the Requirements. Piles shall be designed to sustain the specified loads with settlements not exceeding those specified. Allowance shall be made in the design for the incidence of negative skin friction where appropriate and for resisting the necessary tensile forces due to the swelling and heave of any soil stratum. Piles shall be designed to have a bearing capacity of at least 2.5 times the working load. In extreme cases (such as Earthquake loading case), piles shall be designed to have a bearing capacity of at least 2.0 times the extreme load.

If pile tests are carried out, capacity of the piles shall be calculated according to the safety factors given in Section 4.15 instead. In this case, working load bearing capacity and extreme load bearing capacity shall be the taken the same value.

The permissible load of piles shall be modified where necessary to allow for particular conditions: piles in close proximity or in groups, soil strength, groundwater level, and other relevant factors.

For earthquake loading (lateral loadings), the reactions and displacement of the pile group supporting a structure shall be analyzed in 3-dimensions and the displacements in horizontal direction shall be checked. The lateral bearing capacity should be assessed by treating the soil around as ultimate limit state (limit equilibrium) and/or elasto-plastic (p-y curves).

The piles shall be of sufficient cross-section and length to sustain loads specified without settlement exceeding the following:

* 1.0 x working load Allowable settlement 8 mm
* 1.5 x working load Allowable settlement 10 mm
* 2 x working load Allowable settlement 12 mm

These settlements shall include both permanent and elastic deflections. Measurement of the settlement shall be made on first achieving the specified load. Measurement of the settlement shall be made at the point of application of the load.

Where piles in place are subjected to handling, stacking and pitching or bending moments and/or shear forces, these shall be combined with the vertical loads (either in compression or tension) to satisfy the design requirements.

The average compressive stress in the concrete of bearing piles under working load shall not exceed 25% of the characteristic cube strength at 28 days, calculated on the total cross sectional area of the pile shaft.

## Preliminary Test Piles

After the Engineer has approved the Contractor’s proposals and calculations for the proposed piling system preliminary test piles shall be constructed as instructed by the Engineer. These shall be loaded to 2.0 times the working load to prove the design and system and to demonstrate that the safe load requirements can be achieved by the piling method proposed.

The preliminary test piles shall be located in places proposed by the Contractor and approved by the Engineer. The Engineer shall be given at least 48 hours notice of commencement of construction of the preliminary pile which is to be test-loaded.

The preliminary test piles shall be constructed / installed in a manner similar to that to be used for the construction of the working piles by the use of similar equipment and materials. Any variation will only be permitted with the prior approval of the Engineer.

The pile shafts shall be extended where necessary above the cut-off level or working piles so that gauges and other apparatus to be used in the testing process will not be damaged by water or failing debris and to permit exposure of the reinforcement.

Where the pile shaft is extended above the cut-off level of the working piles in soils which would influence the load bearing capacity of the pile a sleeve shall be left in place during testing to eliminate friction which would not arise in working piles.

If the cut-off level is below ground level and the shaft is not extended and there is a risk of the borehole collapsing, a sleeve shall be left in place or inserted above the pile shaft or other means satisfactory to the Engineer shall be employed. Adequate clearance shall be given between the top of the pile shaft and the bottom of the sleeve to permit unrestricted movement of the pile.

For piles that are tested in compression the pile head or cap shall be formed to give a plane surface which is normal to the axis of the pile sufficiently large to accommodate the loading and settlement measuring equipment and shall be adequately reinforced or protected to prevent damage due to the concentrated application of load from the loading equipment.

The pile cap shall be concentric with the test pile and the joint between the cap and the pile shall have a structural strength equivalent to that of the pile.

A sufficient clear space shall be made under any part of the cap projecting beyond the section of the pile so that at the maximum anticipated settlement load is not transmitted to the ground expect through the pile.

The connection between the pile and the loading equipment shall be constructed in such a manner as to provide strength equal to the maximum load which is to be applied to the pile during the test with an appropriate factor of safety on the structural design.

If the preliminary test pile fails to meet the requirements of the Technical Requirements, the piling system proposed will be considered unsatisfactory. The Contractor shall then submit revised proposals and calculations for the approval of the Engineer. Unless otherwise agreed by the Engineer any test pile which has failed the preliminary test will be rejected and the Engineer may instruct the Contractor to provide one or more further test piles and tests to prove his modified system at no additional cost to the Contracting Authority.

## Lengths and Tolerances

The Contractor shall determine the approximate lengths of piles by examination of the available geo-technical information including information obtained from any additional site investigations under the Contractor. The final length of piles shall be decided by constructing the piles to a minimum depth on the basis of the geo-technical information.

Precast piles shall be constructed within the following tolerances:

* in plan, at the working level of the piling rig 0.15 x B in any direction from the designed position. B = pile dimension (diameter or side)
* 1/75 from the vertical for a vertical pile

The cross-sectional dimensions of the pile shall not be less than those proposed by the Contractor nor should they exceed them by more than 0.015 x B (B = pile dimension, diameter or side). No face of a precast pile shall deviate by more than 6 mm from a straight edge 3 m long laid on the face. The centroid of any cross section of the pile shall not deviate by more than 12 mm from the straight line connecting the centroids of the ends.

## Sequence for Constructions

The sequence of construction of piles shall be to the approval of the Engineer and shall be arranged so as to minimise the vertical and lateral displacement of piles already installed. Levels of the tops of adjacent piles or the structures founded upon them or any other structure shall be measured at intervals while a pile is being installed. Driven piles driven which have risen, shall be re-driven or forced down to the original resistance.

## Handling of Precast Piles

Precast (pre-stressed) concrete piles shall be handled, transported, and stored by methods that will not injure the pile. The piles shall be supported while being handled, transported, and stored, at the pick-up points shown on the plans, or else shall be supported along their full length. Piles damaged in handling or driving shall be replaced by the Contractor.

## Driving Piles

The Contractor shall submit for the Engineer’s approval details regarding the suitability efficiency and energy of his driving equipment.

Precast (pre-stressed) concrete piles shall not be driven until the concrete has achieved the specified characteristic strength.

Cast-in-situ driven piles with steel casing shall be bottom driven by using a casing which shall not distort or buckle during driving. Concrete casing shall be driven on the pile shoe using a mandrel.

Each pile shall be driven continuously until the approved set and/or depth has been reached except that the Engineer may permit the suspension of driving will be substantially re-established on its resumption or if he is satisfied that the suspension of driving was beyond the control of the Contractor.

A follower (long dolly) shall not be used except with the approval of the Engineer who will then require the set to be revised to take into account the reduction in the effectiveness of the hammer blow.

The final set of each pile shall be recorded either as the penetration in mm per 10 blows or as the number of blows required to produce a penetration of 25 mm. When a final set is being measured the following requirements shall be met:

a) The exposed part of the pile shall be in good condition without damage or distortion.

b) The dolly and packing if any shall be in sound condition.

c) The hammer blow shall be in line with the pile axis and the impact surfaces shall be flat and at right angles to the pile and hammer axis.

The Contractor shall give adequate notice and provide all facilities to enable the Engineer to check driving resistances. A set for the purposes of the Contractor shall only be taken in the presence of the Engineer unless otherwise agreed.

At the start of the work and in new areas or sections, sets shall be taken at intervals during the last 3 m of driving to establish the behaviour of piles.

The Contractor shall inform the Engineer without delay if an unexpected change in driving characteristics is noted. A detailed record of driving resistance over the full length of the nearest available pile shall be taken.

Redrive checks if required shall be carried out by a procedure to be agreed by the Engineer.

Piles shall be driven in an approved sequence to minimise the detrimental effects of heave and lateral displacement of the ground.

Measurements shall be taken to determine the movement of ground or any pile resulting from the driving process when required by the Engineer.

Where piles have risen or moved out of plumb as a result of driving adjacent piles the Contractor shall submit to the Engineer his proposals for correcting such faults and their avoidance in subsequent work.

Where preboring is required by the Contractor each pile shall be pitched into a hole prebored before driving to the required depth.

Jetting may be carried out only when approved by the Engineer and the Contractor shall submit detailed proposals and it shall not normally be undertaken over the last 3 m of penetration.

Pile driving shall be refused at the point where driving resistance exceeds either 300 blows per 0.3 meter (roughly 1 mm per blow) for five consecutive 0.3 meters (1.5 meters); or 800 blows for 0.3 meter of penetration .

If there has been a delay in pile driving operations for one hour or longer, the refusal criteria stated above shall not apply until the pile has been advanced at least 0.3meter following the resumption of pile driving. However, in no case shall the blow count exceed 800 blows for 152 mm of penetrations. Detail criteria is given in API 2A-WSD (2000) clause 12.5.6, for steel driving piles

For concrete piles, driving stresses shall be checked and shall not exceed the following values:

* 0.85 f'c (compression)
* 0.7 fy of steel reinforcement (tension)

Driving stresses may be estimated by performing wave equation analyses or by dynamic monitoring of force and acceleration at the pile head during pile driving.

## Repair and Lengthening of Piles

In preparation for repairing the head of a pile the concrete shall be cut off square at sound concrete to expose the reinforcement and all loose particles shall be removed by wire brushing followed by washing with water.

If the pile is to be subjected to further driving the head shall be replaced with concrete of an approved class.

If the pile has been completely driven but the sound concrete is below cut-off level the pile shall be made good to cut-off level with concrete of a class not inferior to that of the concrete of the pile.

In preparation for lengthening a normal reinforced pile the concrete shall be cut off square to expose a sufficient length to ensure that the full strength of the bars will be developed across the joint.

Welded joints shall be made in accordance with DIN 1910 and before welding the main longitudinal reinforcing bars in the head of the pile shall be exposed for at least 300 mm below the position of the weld.

For lap or splice joints sufficient link bars shall be provided to resist eccentric forces.

If the pile is to be subjected to further driving the additional length shall be of an approved grade of concrete. Piles shall not be driven until the added concrete has reached the specified characteristic strength of the concrete of the pile.

## Reinforcement

Unless otherwise dictated by the design, cast in situ piles shall be reinforced over the whole of their length. The minimum longitudinal reinforcement shall be 1.0% of the gross concrete area in the top 3m of the pile and 0.8% of the gross concrete area in the remainder of the pile. Lateral ties shall be provided to maintain the alignment of the longitudinal reinforcement at centres not closer than 150 mm.

Unless otherwise dictated by the design, reinforcement in precast concrete piles shall comply with the following minimum requirements:

* Areas of longitudinal reinforcement of 12 mm diameter minimum shall be at least 1% of the gross concrete area (cast in-situ and precast concrete piles)
* Lateral reinforcement shall be in the form of hoops or links not less than 6 mm diameter. Over a distance of 3 times the width of the pile measured from each end of the pile the volume of lateral reinforcement shall be not less than 0.6 % of the gross volume. In the body of the pile, lateral reinforcement shall be not less than 0.4% spaced at not more than half the width of the pile. The transition between the close spacing near the ends and the maximum spacing shall be made gradually over a length equal to 3 times the width.

Piles of rectangular cross section shall have a minimum of 4 No. longitudinal reinforcement bars and piles of circular cross section shall have a minimum of 6 No. longitudinal reinforcement bars. Bars shall be 12 mm diameter minimum. The main longitudinal bars shall be level at the top of the pile and fit tightly into the shoe if one is used.

Hoops and links shall fit tightly against longitudinal bars and be bound to them by welding or soft iron wire with the free ends turned inwards. The longitudinal bars shall be held apart by spreader forks not more than 1.5m apart.

The main longitudinal reinforcing bars in piles not exceeding 12 m length shall be in one continuous length unless otherwise specified elsewhere. In piles exceeding 12 m in length joints will be permitted in main longitudinal bars at 12 m nominal intervals. Joints in adjacent bars shall be staggered at least 1 m apart along the length of the pile. Joints shall be such that the full strength of the bar is effective across the joint.

The cover to the outermost reinforcement, including binding wire shall not be less than 75 mm measured to the inside of the casing. Lap or splice joints shall be provided with sufficient link bars or other elements to resist eccentric forces. Laps shall have a minimum length of 50 times the diameter of the main longitudinal reinforcement.

Driven piles shall be provided with flat or pointed co-axial shoes of cast iron if driving is liable to damage the concrete at the tip of the pile.

Cast iron pile shoes shall be made from “chill hardened” iron of the grade used for making grey iron castings. The chilled iron point shall be free from major blow holes and other surface defects.

## Records

The Contractor shall maintain a complete record of all piling works which shall include the following where relevant:

* Pile type and number
* Nominal diameter or dimension and pile length
* Date concreted and date driven
* Depth from ground level to toe of pile
* Depth from ground level bearing stratum
* Final set, weight and drops of hammer
* Details of any obstructions observed

All records shall be accurately kept in duplicate as the work proceeds and one copy shall be handed to the Engineerat the completion of each day’s work.

## Precast Reinforced Concrete Piles

Precast reinforced concrete piles shall be designed cast and cured to develop the strength necessary to withstand the transporting, handling and driving stresses without damage. Square piles shall have chamfered corners. Manufacturing and curing shall be in accordance with the xxxxx

Any precast concrete pile section shall be checked against handling, stacking and storing stresses. In computing stresses due to handling, the static loads shall be increased by 50% as an allowance for impact and shock.

## Cast-In-Situ Piles

### Driven or Bored Cast-In-Situ-Piles

Driven or bored cast-in-situ piles shall comprise a temporary or permanent casing of steel, or a permanent casing of precast concrete, augered or driven to a set and completely filled with dense concrete reinforced with steel bars.

All joints in the casing and between the casing and shoes where applicable shall be watertight during driving and completion of driven cast-in-situ piles. Permanent casing shall be inspected, e.g. by using a light lowered from the top after installation to ensure that the casing is neither damaged nor deformed and that all loose soil has been removed from the bottom of bored piles.

Drilling mud shall not be used unless otherwise approved by the Engineer.

### Casing for Cast-In-Situ Piles

The casing shall be suitable for the method of installation and for the purpose of jointing piles. The casing shall either be permanent or temporary.

Steel casing shall be delivered to site in lengths as long as can be conveniently handled. Ends shall be prepared for butt welding and designed to maintain true alignment of the pile.

Joints between steel casings shall be made by butt welding according to DIN 1910 so that the full strength of the original section is developed. Welded joints shall be watertight.

### Concrete Cast-In-Situ Piles

(Prestressed) concrete in cast-in-situ piles shall be in accordance with the requirements of Sub-clause 1.1, 1.12 and 1.13. The slump for the concrete shall be agreed with the Engineer prior to concreting preliminary test piles. Concrete filling in cast-in-situ piles shall be placed continuously. Removal of temporary casings must be completed before the placed concrete loses its workability, but placing of concrete shall keep in advance of withdrawal of casing to prevent ‘necking’.

If the groundwater table in the leachate treatment plant area is close to the ground surface, special care shall be taken while concreting piles under water. All concreting works both in dry and under water conditions shall be performed according to:

* EN 1536: Execution of special Geotechnical Work: Bored Piles-Part 8

Pile heads shall be stripped down and bonded into the pile caps as specified for precast concrete piles.

## Pile Load Tests

Pile load tests shall be carried out in the following situations:

* When using a type of pile or installation method that is outside comparable experience and which has not been tested under comparable soil and loading conditions
* When using a piling system which is outside the experience of the operatives carrying out the work
* When the piles will be subject to loading for which theory and experience do not provide sufficient confidence in the design. The pile testing procedure should then provide loading similar to the anticipated loading
* When observations during the process of installation indicate pile behaviour that deviates strongly and unfavourably from the behaviour anticipated on the basis of the site investigation or experience when additional ground investigations do not clarify the reasons for this deviation

Load test can be statically or dynamical.

If a load test is carried out, it shall normally be located where the most adverse ground conditions are believed to occur. If this is not possible, an allowance shall be made when deriving the characteristic value of the bearing resistance.

If load tests are carried out on two or more test piles, the test location shall be representative of the site of the pile foundations, and one of the test piles shall be located where the most adverse ground conditions are believed to occur.

Between the installation of the test pile and the beginning of the load test, adequate time shall be allowed to ensure that the required strength of the pile material is achieved and the pore pressures have regained their initial values.

### Static Load Tests

*Loading Procedure*

The pile load test procedure, particularly with respect to the number of loading steps, the duration of the loading steps and the application of load cycles, shall be such that conclusions can be drawn about the deformation behaviour, creep and rebound of a pile foundation from the measurements on the pile. For trial piles, the ultimate loading shall be such that conclusions can also be drawn about the ultimate failure load.

Static load tests shall be carried out in accordance with the respective standard. In case of different wording the text in this Technical Requirements shall be valid prior to the above mentioned recommended procedure.

Devices for the determination of forces, stresses or strains and displacements shall be calibrated prior to the test.

In general, pile load tests for the purpose of designing a tensile pile foundation should be carried out to failure. Extrapolation of the load-displacement graph for tension tests should normally not be used, especially in the case of transient loading.

### Trial Piles

The number of trial piles required to verify the design shall be selected on the following aspects:

the ground conditions and their variability across the site

type of structure

documented evidence of the performance of the same type of pile in similar ground conditions

the total number and types of piles in the foundation design

The ground conditions at the test site shall be investigated thoroughly. The depth of borings or field tests shall be sufficient to ascertain the nature of the ground both around and beneath the pile tip. It shall include all strata likely to contribute significantly to pile deformation behaviour, at least 5 times the diameter beneath the pile tip, unless sound rock or very hard soil is found at a lesser depth.

The method used for installation of the trial piles shall be fully documented in accordance with Sub-clause 1.18.1.

### Working Piles

The number of working pile load tests shall be selected on the basis of the recorded findings during construction.

The selection of the working test piles should be prescribed in the contract documents.

The load applied to the working test piles shall be at least equal to the design load governing the design of two foundations.

### Dynamic Load Tests

Dynamic load tests shall be carried out in accordance with the respective standard.

The results of dynamic load tests may be used for design provided an adequate site investigation has been carried out and the method has been calibrated against static load tests on the same type of pile, of similar length and cross-section, and under comparable soil conditions.

Dynamic load tests may be used as an indicator of the consistency of the piles and to detect weak piles.

In a dynamic load test the pile is instrumented with accelerometers and strain gauges. The gauges are connected to a recording and data processing device. During blows on the pile signals from the gauges are recorded and processed for assessment of pile bearing capacity. The data processing will be one of two kinds, either simple or signal matching (CASE or similar program).The simple method gives instant results while signal matching is more time consuming (hours).

In the CASE method or similar the following data shall be registered and reported:

* bearing capacity
* toe resistance and skin friction
* maximum compression stress, acceleration, velocity and displacement
* maximum tension stress in pile
* pile structural integrity; extent and location of damage
* maximum energy transferred to the pile
* blows per minute for hammer check
* blow number
* input and reflection of force, velocity, upward and downward force waves
* load versus deflection of cushions and of pile toe bearing

CAPWAP or similar programs determines that set for soil resistance parameters which produces the best match between measured and computed pile top force and velocity. After CAPWAP analysis additional information than above for CASE is accomplished as:

* deformation properties, ultimate capacities and soil damping parameters for each soil segment of normally 1 m length
* unit skin friction for each segment and end bearing
* maximum of tension and compression forces and stresses
* pile structural damping
* dynamic pile toe displacement
* graph on bearing capacity and pile stresses versus blow count

An introductory program (WEAP) can be utilised before pile driving to assess preliminary combinations of sets and bearing capacities for specified pile, driving equipment and soil conditions.

The data processing shall be carried out by well experienced experts.

The piles to be tested are selected as in these ER.

### Dynamic Load Test Procedure

The Contractor shall notify the Engineer at least two weeks prior to dynamic testing.

The Contractor shall submit a qualified testing Consultant and his experience to the Engineer for approval.

The Engineer shall determine if the test is to be performed or if some pile waiting periods at the proposed site is required before a decision will be made.

The Engineer will establish a date for the tests and will also determine the location of all piles to be dynamically load tested.

### Dynamic Load Test Procedure on Driven Piles

The Contractor shall supply all personnel and equipment needed to strike the test pile with the hammer.

The Contractor shall provide the hammer (drop, diesel, etc.) or the mobile crane to lift a steel ram weight by a single non-twisting cable and be able to strike to the pile top by mean of full-gravity-fail.

The instrument for the dynamic load test shall conform to the standards, e.g.ASTM D 4945.

Approximately two driven piles will be tested in one day. The testing Consultant personnel will drill holes into the pile to be tested so that transducers (two accelerometers and two strain gauges) can be attached. Testing procedures shall be conformed to e.g. ASTM D 4945.

When the transducers have been placed in position and the recording and processing equipment has been made ready to receive the acceleration and strain measurements, the Engineer will instruct the Contractor regarding the drop height and the Contractor shall strike the driven pile with the hammer as many times as is required to obtain adequate measurements as determined by the Engineer.

The Engineer may ask the Contractor to provide surveying instrument to monitor the pile set after each strike.

After the dynamic testing measurements have been obtained and analysed and a report has been submitted, the Engineer will provide instructions for the results.

### Dynamic Load Test Procedure on Bored Piles

The Contractor shall prepare the pile top and if necessary improve the structural integrity of the pile top to resist a sharp impact force. All loose concrete at the pile top shall be removed. The top portion of the bored pile shall be extended to a length of at least two times the diameter of the bored pile with the same diameter as the bored pile. The extended portion of the bored pile shall be cast with concrete having a minimum compressive strength of 40 MPa.

Additional shear reinforcement such as spiral hoop at the pile top is recommended for the impact force. The Contractor shall provide the windows for the installation of instrument by burning an opening 0.35 x 0.35 m2 to the steel casing using a cutting torch.

On top of the bored pile a timber cushion under steel plate as a hammer cushion shall be mounted. Adhesive material may be applied between the pile top and the timber.

The Contractor shall provide an additional steel casing inserted into the pile top. This casing is acting as a guide for the steel ram weight, having the length not less than the summation of the drop height and the length of the steel ram weight. It is important to secure and stabilise the steel casing by means of a vibratory hammer.

The Contractor shall supply all personnel and equipment needed to strike the test pile with the steel ram weight. The Contractor shall provide a mobile crane which has the ability to lift the steel ram weight by a single non-twisting cable and be able to strike to the pile top by mean of full-gravity-fail.

The instrument for the dynamic load test shall conform to e.g. ASTM D 4945.

Approximately one bored pile will be tested in one day. The testing Consultant personnel will drill holes in the windows of the left-in-place steel casing into the pile to be tested so that transducers (two accelerometers and two strain gauges) can be attached.

Testing procedures shall be conformed to e.g. ASTM D 4945.

The Engineermay ask the Contractor to provide surveying instrument to monitor the pile set after each strike.

After the dynamic testing measurements have been obtained and analysed and the report has been submitted, the Engineerwill provide instructions for the results.

### Load Test Report

The Contractor shall submit a complete record of each pile test to the Engineer24 hours after completion of the tests. Where appropriate, this report shall include:

* a description of the site
* the ground conditions with reference to ground investigations
* the pile type
* a description of the loading and measuring apparatus and the reaction system
* calibration documents of the load cells, the jacks and the gauges
* the installation record of the test piles
* photographic records of the pile and the test site
* test results in numerical form
* time settlement plots for each applied load when a step loading procedure is used
* the measured load-settlement behaviour
* justification of the reasons for any departures from the recommendations

## Piles in Compression

### Ultimate Bearing Resistance from Static Pile Load Tests

The manner in which load tests are carried out shall be in accordance with these TR.

Trial piles to be tested shall be installed in the same manner as the piles which will form the foundation and shall be founded in the same stratum.

In the case of a very large diameter pile, it is often impractical to carry out a load test on a full size trial pile. Load tests on smaller diameter trial piles may be considered provided that:

the ratio of the trial pile/ working pile diameter is not less than 0.5

the trial pile is instrumented in such a manner that the base and shaft resistance can be derived separately from the measurements

When deriving the ultimate characteristic bearing resistance Rcc from values Rcms measured in one or several static pile load tests, an allowance shall be made for the variability of the ground and the variability of the effect of pile installations a minimum, both conditions (a) and (b) of the table below shall be satisfied using the equation:

Rcc = Rcms/γns

Factors γns to deduce Rcc

Number of Load Tests 1 2 > 2

γns on average Rcms 1.5 1.35 1.3

γns on lowest Rcms 1.5 1.25 1.1

In order to derive the ultimate design bearing resistance, the characteristic value Rcc should be divided into components of base resistance Rcbc and shaft resistance Rcsc such that

Rcc = R cbc + Rcsc

The design bearing resistance Rd shall be derived from

Rcd = Rcbc/ γbs + Rcsc/γss

where γbs and γss are taken from the table below.

Values of γbs, γss and γts

Component Factors γbs γss γts

Driven piles 1.3 1.3 1.3

Bored piles 1.6 1.3 1.5

CFA piles 1.45 1.3 1.4

In general, the load test only provides the pile load test versus settlement and time versus settlement diagrams without distinction between point and shaft resistance. Therefore, it is often not possible to distinguish between partial factors for the assessment of the design value of base resistance and shaft resistance. Instead a partial factor on the ultimate characteristic pile resistance Rcc may taken as the γts values given in the table above.

### Ultimate Bearing Resistance from Pile Driving Formulae

If pile formulae are used to assess the ultimate bearing resistance of individual compression piles in a foundation, the validity of the formulae shall have been demonstrated by previous experimental evidence of good performance or static load tests on the same type of pile, of similar length and cross-section, and in similar ground conditions.

Pile driving formulae shall only be used if the stratification of the ground has been determined.

In the design, the number of piles to be redriven shall be specified. If redriving gives lower results, these shall be used as basis for ultimate bearing resistance assessment. If redriving gives higher results, these may be taken into consideration.

Redriving should usually be carried out in silty soils, unless local comparable experience has shown this to be unnecessary.

### Ultimate Bearing Resistance from Dynamic Load Tests

Dynamic load tests and their evaluation can be used to assess pile bearing resistance of individual compression piles. The validity of the evaluation shall have been demonstrated by previous evidence of acceptable performance or static load tests on the same pile type of similar length and cross-section and in similar soil conditions. The input energy level during the dynamic load testing shall be high enough to allow for an appropriate interpretation of the pile capacity at a correspondingly high enough strain level.

When deriving the ultimate characteristic bearing resistance Rcc from values Rcmd measured in two or several dynamic pile load tests, an allowance shall be made for the variability of the ground and the variability of the effect of pile installations a minimum, both conditions (a) and (b) of the table below shall be satisfied using the equation:

Rcc = Rcmd /γnd

Factors γnd to Derive Rcc

Number of Load Tests 2 4 > 4

γns on average Rcms 1.5 1.35 1.3

γns on lowest Rcms 1.5 1.25 1.1

In order to derive the ultimate design bearing resistance, the characteristic value Rcc should be divided into components of base resistance Rcbc and shaft resistance Rcsc such that

Rcc= Rcbc + Rcsc

The design bearing resistance Rcd shall be derived from

Rcd = Rcbc/γbd + Rcsc/γsd

where γbd and γsd are taken from the table below

Values of γbd, γsd and γtd

Component Factors γbd γsd γtd

Driven piles 1.4 1.4 1.4

Bored piles 1.7 1.4 1.6

In case Rcbc and Rcsc are not known the design bearing resistance Rcd is derived from

Rcd = Rcc/γtd

## Piles in Tension

Pile load tests to determine the ultimate tensile resistance Rtc of an isolated pile shall be carried out in accordance with these TR.

When deriving the ultimate characteristic resistance Rtc from values Rtm measured in one or several static pile load tests, an allowance shall be made for the variability of the ground and the variability of the effect of pile installation. As a minimum, both conditions (a) and (b) of the table below shall be satisfied using the equation:

Rtc = Rtms/γnt

Number of Load Tests 1 2 > 2

γns on average Rcms 1.5 1.35 1.3

γns on lowest Rcms 1.5 1.25 1.1

Normally when piles are loaded in tension, more than one pile shall be tested. In the case of a larger number of tension piles, at least 2% shall be tested.

The design tensile resistance, Rtd, shall be derived from

Rtd = Rtc/γm

where γm = 1.6

## Supervision of Construction

A pile installation plan shall be the basis for the construction work.

The plan should give the following design information:

* the pile type with designation if standardised or technical approval otherwise
* the location and inclination of each pile and tolerances on position
* pile cross-section
* pile length
* number of piles
* required pile load carrying capacity
* pile toe level or the required penetration resistance
* installation sequence
* any other constraints on piling activities

The installation of all piles shall be monitored and records shall be made at site and as the piles are installed. A record signed by the Engineer of the work and the pile manufacturer shall be kept for each pile.

The record for each pile shall include the following, where appropriate:

* pile type and installation equipment
* pile number
* pile cross-section, length and (for concrete piles) reinforcement
* data and time of installation (including interruptions to the construction process)
* concrete mix, volume of concrete used and method of placing for cast-in situ piles
* pumping pressures of the grout or concrete, internal and external diameters, pitch of screw and penetration per revolution (for continuous flight auger piles or other injection piles)
* for driven piles, the values of driving resistance measurements such as weight and drop or power rating of hammer, blow frequency and number of blows for at least the last 0.25 m penetration
* the power take-off of vibrators (where used)
* the torque applied to the drilling motor (where used)
* for bored piles, the strata encountered in the borings and the condition of the base, if performance of the base is critical
* obstructions encountered during piling
* deviations of positions and directions and as-built elevations

Records shall be kept for a period of at least 5 years after completion of the works. As built record plans shall be compiled after completion of the piling and kept with the Drawings.

If site observations or inspection of records reveal uncertainties with respect to the quality of installed piles, additional investigations shall be carried out the determine the as-built conditions of the piles and whether remedial measures are necessary. These investigations shall include either redriving or pile integrity tests, in combination with soil mechanics field tests adjoining the suspected piles, and static pile load tests.

Tests shall be used to examine the integrity of piles for which the quality is sensitive in a reliable way.

Dynamic low strain integrity tests can be used for a global evaluation of piles that might have severe defects or that may have caused a serious loss of strength in the soil during construction. Since defects like insufficient quality of concrete and thickness of concrete cover, affecting the long term performance of a pile, often cannot be found by dynamic tests, other tests such as sonic tests, vibration tests or coring may be needed in supervising the execution.

## Ground Treatment

Any ground treatment proposed by the Contractor to improve the bearing capacity and/or settlement characteristic of the soil must be supported by a full method statement and design calculations with a statement of the minimum performance to be achieved. Where directed by the Engineerthe Contractor shall carry out a field trial of the proposed treatment to demonstrate that it meets the stated performance criteria.

## Permanent Steel (Sheet) Piles

### Standards

In additional to the standards as listed the following standards shall apply:

DIN 4124 Excavations and slopes, sheeting and bracing

DIN 4125 Grout anchors, design, execution and testing

DIN 4128 Small grout piles

EN 1537 Grout anchors, design, execution and testing

EN 12063 Sheet pile walls

ENV 1997 Eurocode 7 : geotechnical design

### General

The work covered by this section consists of furnishing and driving of steel (sheet) piles which are to be left in place so that they become a part of the completed work, all in conformity with the requirements shown on the Drawings or in these specifications.

Application shall be retaining walls and pile foundation, only.

The Contractor shall carry out detailed design of these structures in accordance with the Contract Conditions and Technical Requirements and shall determine the type of foundation or supporting wall required, the number of piles and their working loads and the optimum arrangement of piles required for supporting the structures or walls.

Excavation and steel where applicable shall conform to the relevant Clauses of the Technical Requirements.

At least 21 days before the Contractor intends to commence piling work on the site the Contractor shall submit for the Engineer’s approval full details of his proposed piling system including the type and dimensions of piles, reinforcement details and full details and full design and driving calculations. The details to be submitted shall include the Contractor’s proposals for equipment, temporary works and construction methods.

No work on piling shall commence on the site until the Engineer’s approval to the Contractor’s proposal has been received.

### Material Quality

The following strength classes shall apply:

EN 10027-1 EN 10027-2 old German name

S275JO 1.0143 St 44-3 U

S355JO 1.0553 St 52-3 U

## Cutting and Welding

No cutting or welding of piles shall be carried out without prior written approval from the Engineer. All such cutting shall be carried out by means of oxyacetylene, oxypropane or other approved method. The remaining pile shall be of clean and even appearance with grinding tools being employed to remove splatter. Cut-offs shall be marked so that it is clear from which pile they came and after agreement from the Engineerwill be disposed of in the pre agreed manner. Cutting must be carried out in such a way as to prevent damage or distortion to adjacent piles. The finished level of the cut pile shall be within 20 mm of the theoretical level.

Only welders who are qualified to the standard set out in Sub-clause 16.33.7 Welding of Pipelines and have a proven record over the previous 6 months, or who have attained a similar standard, shall be employed on the works. Proof of welder proficiency shall be made available to the Engineer on request.

Defective welds shall be cut out and replaced. Where steel sheet piles are to be spliced by butt welding, the interlocks shall not be welded unless a sealing weld is required. Butt welding should only be carried out if the component ends have been matched together to ensure best possible fit

### Cutting Sheet Piles

When it is necessary to form holes in the sheet piles, they shall be drilled or burnt using a template, and subsequently dressed flush. The hole size shall be of sufficient clearance and will include allowance for bolt/tie coatings and inclination if not horizontal. All holes not required in the finished works which are not sealed in the pile cap or other such detail, shall be sealed by welding a plate of the same grade, of thickness not less than the pan thickness to the pile. The minimum plate overlap shall be 40 mm and the minimum continuous fillet weld size shall be 6 mm.

All holes shall be within a positional tolerance of ± 10 mm.

Holes formed as weep holes to avoid water build up behind the wall shall comply with the above details.

## 

# Retaining Walls

## Design

Design of the retaining wall structure shall consider ultimate and serviceability limit states.

Ultimate limit states shall include instability of the structure as a whole including the soil mass, failure of the structure by bending or shear and excessive deformation of the wall or soil to the extent that adjacent structures or services are affected. Serviceability limit states shall include limited deformation of the structure and movement of the ground.

Surcharges and externally applied loads on each side of the wall: a minimum surcharge of 0.01 MPa on the retained side of the wall shall be used in design.

A minimum unplanned depth of excavation in front of the wall of 0.5 m or 10% of the retained height of a cantilever or 10% of the distance below the lowest support in a supported wall shall be included. In the case of a retaining structure with services buried in the passive zone, allowance shall be made for future excavation to replace or maintain the cables or pipes.

In permanent structures, the long term performance of the steel used must be considered.

Weep holes shall be provided behind the wall for drainage.

Sheet piles sections shall consider stresses caused by driving forces

The design shall consider full hydrostatic pressures behind the wall where this can occur.

## Profiles

The steel sheet piles shall be LX or Larssen, in new condition and shall have an appropriate combined section modulus and mass to be submitted to the Engineer for approval.

The corners, junctions and special piles indicated on the working drawings shall be fabricated at the manufacturer’s premises under workshop conditions or similar approved facility with quality assurance systems operative. All such work shall comply (within the tolerances) to the standard dimensions quoted by the manufacturer, or for non standard fabrications to the approval of the Engineer.

If during the course of the works a requirement for extra fabricated piles occurs, the contractor shall submit to the Engineerfor approval, the proposed type and method of manufacture. Piles of the same steel grade and section size as the neighbouring plain piles shall be used, unless otherwise approved.

All materials shall comply with the appropriate standards.

## Tolerances

Width of single pile shall not deviate more than 2% from nominal width.

Width of interlocked piles shall not deviate more than 3% from nominal width of interlocked piles.

Maximal bow shall not exceed 0.2% of total pile length.

Profile height may vary ±4 mm for profiles heights below or equal 200 mm. Profile height may vary ±5 mm for profiles heights above 200 mm.

Flange thickness may vary ±0.5 mm for flange thickness below or equal 8.5 mm. Flange thickness may vary ±6% for flange thickness above 8.5 mm.

Web thickness may vary -0.5 mm for web thickness below or equal 8.5 mm. Web thickness may vary -6% for web thickness above 8.5 mm.

Profiles ends shall be cut plane and perpendicular to profile axis.

## Coating

Steel sheet pile coating protection shall receive the following surface preparation and take the following form:

Sand blast clean to ISO 8501-1, grade 2, then application of high-build isocyanate cured, epoxy pitch (special coal tar pitch, modified with epoxy resins, cured with isocyanate adducts) in coat thicknesses of up to 400 μm or similar approved by the Engineer.

Due care and attention shall be given to the offloading, storing and installation of protected piles to prevent damage to coatings.

Any remedial work to coatings shall be carried out in accordance with the manufacturer’s recommendations and to the satisfaction of the Engineer.

## Capping

The top of the steel sheet pile shall be protected with a cap beam made of reinforced concrete, cross section not less than 40 cm x 40 cm.

# Ground Anchors

Prestressed ground anchors shall consist of high-strength bar or strand tendons grouted into an inclined hole drilled behind the face of the excavation. The ground anchors shall be installed and tensioned as the excavation progresses downward.

Wale beams shall be secured to each pair of piles with anchor bolts, washers and bearing plates. All splices, if welded or bolted, shall be at the fifth spacing between ground anchors and splices in wale beams and shall be staggered by a minimum distance of 5 m.

Quality and material of tendons shall comply with these TR.

Tendons shall not be used for earthing purposes and will be protected against welding splash. Tendons shall be assembled with necessary taper washers, washers and bearing plates in accordance with the manufacturer’s recommendations.

Tendons and fittings shall be protected against corrosion by appropriate and approved means.

## Working Drawings

The Contractor shall submit to the Engineerworking drawings and design submittals that shall include the following:

* Ground anchor schedule giving:
* Ground anchor number
* Ground anchor design load
* Type and size of tendon
* Minimum total anchor, bond, tendon bond, unbonded length
* Drawing of the ground anchor tendon and the corrosion protection system including details for the following:
* Spacers, centralises, anchorage and trumpet and their location
* Corrosion protection system for the bond and unbonded length and anchorage
* Certificates of Compliance for the following materials, if used. The certificate shall state that the materials or assemblies to be provided will fully comply with the requirements of the Contract.
* Prestressing steel, strand or bar
* Portland cement
* Prestressing hardware
* Bearing plates
* Corrosion protection system

## Tendon Bond Length Encapsulations

When the Drawings require the tendon bond length to be encapsulated to provide additional corrosion protection, the encapsulation shall be fabricated from corrugated HDPE with adequate wall thickness

## Heat Shrinkable Sleeves

Heat shrinkable sleeves shall be fabricated from a radiation crosslinked polyolefin tube internally coated with an adhesive sealant. Prior to shrinking, the tube shall have an adequate wall thickness of.

## Heath

A sheath shall be used as part of the corrosion protection system for the unbonded length portion of the tendon. The sheath shall be fabricated from a PE tube pulled or pushed over the prestressing steel.

## Bondbreaker

The bondbreaker shall be fabricated from a smooth plastic tube or pipe being resistant to chemical attack from aggressive environments, grout, or corrosion inhibiting compound; being resistant to ageing by ultraviolet light; being fabricated from material non detrimental to the tendon; being capable of withstanding abrasion, impact, and bending during handling and installation; and shall enable the tendon to elongate during testing and stressing; and shall allow the tendon to remain unbonded after lock-off.

## Corrosion Inhibiting Compound

The corrosion inhibiting compound placed in either the free length or the trumpet areas shall be an organic compound (i.e. grease or wax) with appropriate polar moisture displacing, corrosion inhibiting additives and self healing properties. The compound shall permanently stay viscous and be chemically stable and non-reactive with the prestressing steel, the sheathing material, and anchor grout.

## Grout Tubes

Grout tubes shall have an adequate inside diameter to enable the grout to be pumped to the bottom of the drill hole. Grout tubes shall be strong enough to withstand the grouting pressure

## Drilling

Drilling methods shall be left to the discretion of the Contractor, whenever possible. The Contractor shall be responsible for using a drilling method to establish a stable hole of adequate dimensions, within the tolerances specified. Drilling methods may involve, amongst others, rotary, percussion, rotary/percussive or auger drilling; or percussive or vibratory driven casing.

Holes for anchors shall be drilled at the locations and to the length, inclination and diameter shown on the approved working Drawings. The drill bit or casing crown shall not be more than 3 mm smaller than the specified hole diameter. The ground anchor hole shall not be drilled in a location that requires the tendon to be bent in order to enable the bearing plate to be connected to the supported structure.

At the point of entry the ground anchor shall be installed within ±3 degrees of the inclination from horizontal shown on the approved working Drawings. At the point of entry the horizontal angle made by the ground anchor and the structure shall be within ±3 degrees of a line drawn perpendicular to the plane of the structure unless otherwise shown on the approved working Drawings. The ground anchors shall not extend beyond the right-of-way or easement limits shown on the contract Drawings.

## Tendon Insertion

Tendons shall be placed in accordance with the approved working Drawings and details and the recommendations of the tendon manufacturer or specialist anchor contractor. The tendon shall be inserted into the drill hole to the desired depth without difficulty. When the tendon cannot be completely inserted, the Contractor shall remove the tendon from the drill hole and clean or redrill the hole to permit insertion. Partially inserted tendons shall not be driven or forced into the hole.

Each anchor tendon shall be inspected by Engineer during installation into the drill hole or casing. Damage to the corrosion protection system shall be repaired, or the tendon replaced if not repairable. Loose spacers or centralises shall be reconnected to prevent shifting during insertion. Damaged fusion-bonded epoxy coatings shall be repaired in accordance with the manufacture’s recommendations.

The rate of placement of the tendon into the hole shall be controlled such that the sheathing, coating, and grout tubes are not damaged during installation of the tendon. Anchor tendons shall not be subjected to sharp bends.

## Grouting

The Contractor shall use a neat cement grout or a sand-cement grout with Portland cement (CEM I) class CE I 32.5, 42.5 or 52.5 in accordance to EN 197. The cement shall not contain lumps or other indications of hydration. Admixtures, if used, shall be mixed in accordance with the manufacture’s recommendation.

The grouting equipment shall produce a grout free of lumps and undispersed cement. A positive displacement grout pump shall be used. The pump shall be equipped with a appropriate pressure gauge to monitor pressures. The grouting equipment shall be sized to enable the grout to be pumped in one continuous operation. The mixer should be capable of continuously agitating the grout.

The grout shall be injected from the lowest point of the drill hole. The grout may be pumped through grout tubes, casings, hollow-stem-augers, or drill rods. The grout can be placed before or after insertion of the tendon. The quantity of the grout and the grout pressures shall be recorded. The grout pressures and grout takes shall be controlled to prevent excessive heave or fracturing.

After the tendon is installed, the drill hole may be filled in one continuous grouting operation except that pressure grouting shall not be used in the free length zone. The grout at the top of the drill hole shall not contact the back of the structure or the bottom of the trumpet.

If the ground anchor is installed in a fine-grained soil using drill holes larger than 15 cm in diameter, then the grout above the top of the bond length shall be placed after the ground anchor has been tested and stressed. The Engineer will allow the Contractor to grout the entire drill hole at the same time if the Contractor can demonstrate that their particular ground anchor system does not derive a significant portion of its load-carrying capacity from the soil above the bond length portion of the ground anchor.

The grout tube may remain in the hole on completion of grouting if the tube is filled with grout.

After grouting, the tendon shall not be loaded for a minimum of 3 days.

## Anchorage Installation

The anchor bearing plate and the anchor head or nut shall be installed perpendicular to the tendon, within ±3 degrees and centred on the bearing plate, without bending or kinking of the prestressing steel elements. Wedge holes and wedges shall be free of rust, grout and dirt.

The stressing tail shall be cleaned and protected from damage until final testing and lock-off. After the anchor has been accepted by the Engineer, the stress tail shall be cut to its final length according to the tendon manufacturer’s recommendations.

The corrosion protection surrounding the unbonded length of the tendon shall extend up beyond the bottom seal of the trumpet or 10 cm into the trumpet if no trumpet seal is provided. If the protection does not extend beyond the seal or sufficiently far enough into the trumpet, the Contractor shall extend the corrosion protection or lengthen the trumpet.

The corrosion protection surrounding the unbonded length of the tendon shall not contact the bearing plate or the anchor head during testing and stressing. If the protection is too long, the Contractor shall trim the corrosion protection to prevent contact.

## Corrosion Protection

The corrosion protection systems shall be designed and constructed to provide reliable ground anchors for temporary and permanent structures.

All stressing anchorages permanently exposed to the atmosphere shall receive a grout-filled cover, except, for re-stressable anchorages, a corrosion inhibiting compound must be used. Stressing anchorages encased in concrete at least 5 cm thick do not require a cover.

The trumpet shall be sealed to the bearing plate and shall overlap the un-bonded length corrosion protection by at least 10 cm. The trumpet shall be long enough to accommodate movements of the structure and the tendon during testing and stressing.

The trumpet shall be completely filled with grout, except re-stressable anchorages must use corrosion inhibiting compounds. Compounds may be placed any time during construction. Compound filled trumpets shall have a permanent seal between the trumpet and the un-bonded length corrosion protection. Grout must be placed after the ground anchor has been tested and stressed to the lock-off load. Trumpets filled with grout shall have either a temporary seal between the trumpet and the un-bonded length corrosion protection or the trumpet shall fit tightly over the un-bonded length corrosion protection for a minimum of 10 cm.

Corrosion protection of the un-bonded length is described above.

## Testing - General

Each ground anchor shall be tested. No load greater than 10% of the design load can be applied to the ground anchor prior to testing. The maximum test load shall be no less than 1.33 times the design load and shall not exceed 80% of the specified minimum ultimate tensile strength of the pre-stressing steel of the tendon. The test load shall be simultaneously applied to the entire tendon. Stressing of single-element tendons shall not be permitted.

The testing equipment shall consist of:

* A dial or Vernier scale capable of measuring accurately enough shall be used to measure the ground anchor movement.
* A hydraulic jack and pump shall be used to apply the test load. The jack and two calibrated pressure gauges shall be used to measure the applied load. The jack and all pressure gauges shall be calibrated by an independent firm as a unit. Testing cannot commence until the Engineerhas approved the calibration.
* An electrical resistance load cell and readout to be used when performing an extended creep test.
* The stressing equipment shall be placed over the ground anchor tendon in such a manner that the jack, bearing plates, load cells and stressing anchorage are axially aligned with the tendon and the tendon is centred within the equipment.
* The stressing equipment, the sequence of stressing and the procedure to be used for each stressing operation shall be determined at the planning stage of the project. The equipment shall be used strictly in accordance with the manufacturer’s operating instructions.
* Stressing equipment shall preferably be capable of stressing the whole tendon in one stroke to the specified test load and the equipment shall be capable of stressing the tendon to the maximum specified test load within 75% of the rated capacity. The pump shall be capable of applying each load increment in less than 60 seconds.
* The equipment shall permit the tendon to be stressed in increments so that the load in the tendon can be raised or lowered in accordance with the test specifications, and allow the anchor to be lift-off tested to confirm the lock off load.
* Stressing equipment shall have been calibrated, within an accuracy of ±2%. The calibration certificate and graph shall be available on site at all times.

Dial gauges shall bear on the pulling head of the jack and their stems shall be coaxial with the tendon direction. The gauges shall be supported on an independent, fixed frame, such as a tripod, which will not move as a result of stressing or other construction activities during the operation.

Prior to setting the dial gauges, the Alignment Load (AL) shall be accurately placed on the tendon. The magnitude of the AL depends on the type and length of the tendon.

Regripping of strands, which would cause overlap wedge bites, or wedge bites on the tendon below the anchor head, shall be avoided.

Stressing and testing of multiple element tendons with single element jacks is not permitted.

Stressing shall not begin until the grout has reached adequate strength.

The anchor testing program shall consist of two parts, namely, performance tests and proof tests.

Anchor installations for performance testing within each area shall be as directed by the owner's representative. One anchor per wall area shall be tested in accordance with the performance test procedures. These anchors should be located in the area of soil borings if possible. These anchors are to be installed, tested, and approved by the owner's representative prior to the installation of production anchors within that area. All anchors which are performance tested shall be used as production anchors and incorporated into the retention structure.

Upon completion and approval of the performance tests in an area, the installation of production anchors may proceed.

Proof tests shall be performed on all production anchors which are not performance tested. Proof tests results are subject to the approval of the owner's representative.

### Performance Test Procedures

Two production anchors shall be performance tested. These tests should be located near soil borings if feasible.

The anchors which are performance tested may be completely unloaded prior to adjusting to the lock-off load, if so warranted by the construction sequence. Final loading to the lock-off load does not require further movement readings.

Anchors shall be performance tested in accordance with the following schedule:

Cyclical load increments (%DL/100)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | AL | AL | AL | AL |
| 0.25DL | 0.25DL | 0.25DL | 0.25DL | 0.25DL |
| 0.50DL | 0.50DL | 0.50DL | 0.50DL | 0.50DL |
|  |  | 0.75DL | 0.75DL | 0.75DL |
|  |  |  | 1.00DL | 1.00DL |
|  |  |  |  | 1.25DL |

AL = Alignment Load (10%-15% DL)

DL = Design (Working) Load

The load shall be maintained at each load increment for a sufficient period of time to allow for accurate movement readings to be recorded. This applies to all load increments except the 1.25DL increment.

The 1.25DL load increment shall be held for 10 minutes. The 10 minute observation period shall commence as soon as the 1.25DL load is applied to the anchor. Movements shall be recorded at 0.5, 1, 2, 3, 4, 5, 6, and 10 minutes. If the anchor movement between the 1 minute and 10 minute readings exceeds 1 mm, then the 1.25DL test load shall be maintained for an additional 20 minutes. Movements shall be recorded at 15, 20, 25, and 30 minutes. If the acceptance criteria given below are not satisfied, then the anchor test shall be continued for an additional 30 minutes. Movements shall be recorded at 45 and 60 minutes. If the acceptance criteria are not satisfied after this extended observation period, then the contractor shall exercise one of the options as referenced below.

Throughout the 1.25DL observation period, the load shall be held constant by adjusting the hydraulic pressure. Care must be taken so as not to exceed the 1.25DL test load.

### Proof Test Procedures

All anchors which are not performance tested shall be proof tested.

Anchors which are proof tested may be completely unloaded prior to adjusting to the lock-off load, if so warranted by the construction sequence. Final loading to the lock-off load does not require further movement readings.

Anchors shall be proof tested in accordance with the following schedule:

Loading Schedule

| **Observation** | |
| --- | --- |
| Increment | Period |
| (%DL/100) | (min.) |
| AL | 0.0 |
| 0.25DL | 2.0 |
| 0.50DL | 2.0 |
| 0.75DL | 2.0 |
| 1.00DL | 2.0 |
| 1.25DL | 5.0 |

AL = Alignment Load (10%-15% DL)

DL = Design (Working) Load

The load increments from AL to 1.0DL shall be maintained for a period not to exceed 2 minutes. The 2 minute observation period shall begin when the pump begins to load the anchor to the next load increment. Movement readings shall be taken at the end of the two minute observation period. This does not apply to the 5 minute observation period at 1.25DL test load.

The 1.25DL test load shall be maintained for 5 minutes. This 5 minute observation period shall commence as soon as the 1.25DL is applied to the anchor. Movement readings shall be recorded at 0.5, 1, 2, 3, 4, and 5 minutes. If the movement between the 0.5 and 5 minute reading exceeds 1 mm, then the 1.25DL test load shall be maintained for an additional 5 minutes. Movement readings shall be recorded at 6 and 10 minutes. If the acceptance criteria given below are not satisfied, then the anchor test shall be continued for an additional 20 minutes. Movement readings shall be recorded at 15, 20, 25, and 30 minutes. If the acceptance criteria given below are not satisfied after this extended observation period, then the contractor shall exercise one of the options as referenced below.

Throughout the 1.25DL observation period, the load shall be held constant by adjusting the hydraulic pressure. Care must be taken so as not to exceed the 1.25 test load.

### Acceptance Criteria

The net movement for the performance and proof tests shall not exceed 3 mm during the final log cycle of time (examples, 3-min. to 30-min. for performance tests; 1-min. to 10-min. for proof tests).

If the above criteria are exceeded, then the test shall be continued for an extended period of time as defined for the performance test and for the proof test. If the final log cycle of time movement at the end of the extended observation period exceeds 0.12 then the contractor shall have the following options:

1. Extend the observation period for an additional 60 minutes for the performance test with movement readings taken at 80, 90, 100, and 120 minutes. Extend the observation period for an additional 30 minutes if the proof test is involved with movement readings taken at 45 and 60 minutes. The net movement shall not exceed 3 mm during the final log cycle of time.
2. Install the anchor deeper so as to increase its average installation torque, provided that the maximum torque capacity of the anchor will not be exceeded. This anchor shall be proof tested.
3. Remove the anchor and reinstall an anchor with larger diameter and/or additional helices. If this anchor is reinstalled at the same location, then the last helix of this reinstalled anchor shall penetrate at least 1.5 m beyond the length of the original anchor. This anchor shall be proof tested.
4. Reduce the design load of the anchor. This anchor shall be performance tested at the reduced design load. This option will require one or two additional anchors be installed adjacent to this reduced design load anchor. The number of additional anchors to be installed is a function of the reduced design load. Adjacent anchor(s) shall be installed at least 1.2 m from the reduced design load anchor. Design loads on adjacent anchor(s) shall be adjusted accordingly based on the revised horizontal spacing.

# Steel Pile Foundations

## Profiles

Bearing piles shall be H-section bearing piles, Larssen box piles or tubular piles.

## Tolerances

Tolerances of H-section piles and tolerances of Larssen profiles used for box piles shall be as stated in TR.

## Design, Testing, Driving

For design of piles, preliminary test of piles, lengths of piles, sequence for constructions and driving piles the relevant Clauses of ER shall apply except where stated otherwise below.

Pile load tests, piles in compression, piles in tension shall be in accordance to these ER.

## Repair and Lengthening

In preparation for repairing the head of a pile the profile shall be cut off plane and perpendicular to the profile axis.

If the pile is to be subjected to further driving or the pile has been completely driven but the end is below cut-off level the new profile section shall be welded onto the driven profile section.

Cutting and welding shall be performed in accordance to these ER.

## Piling

### Method Statement

Before the commencement of any piling works, the contractor shall submit 3 weeks before starting the works to the Engineer for approval a safety policy and a method statement which shall include the following information:

* Program of the works detailing sequence and timing of individual portions of the works.
* Maximum proposed lead at any stage of driving between a pile and its neighbour and the limitations of same if hard driving is encountered.
* The height, spacing, stability and type of piling guidance system and the number of piles in each panel if applicable.
* Full details of installation plant to be utilised including manufacturers information, proof of servicing/recent upkeep and assessment of actual input energy to the piles and a definition of driving refusal for each type of plant proposed.
* Proposed phasing of excavation/filling operations such that designed stresses in the piles and frames/supports are not exceeded.
* Contingency plan in the event of encountering obstructions or reaching driving refusal to minimise disruption/delay especially when using pitch and drive methods.
* Details of the envisaged noise production and the Contractor’s intended method of noise minimisation.
* Details of the estimated vibration levels created by the works and the Contractor’s intended method of noise minimisation.

### Handling

All piles shall be stacked in accordance with the manufacturer’s recommendations.

The Contractor shall ensure that operations involving loading, transporting, offloading, handling, stacking and pitching the piles, are carried out in such a manner as to prevent damage to the piles or their coating.

Any damage that does occur shall be drawn to the attention of the Engineer and the Contractor shall submit his proposals for remedial works for approval prior to commencement. The making good/replacement measures shall be carried out by the Contractor at his own expense. The Engineer’s approval of the completed remedial measures will be required before inclusion into the structure can take place.

Holes shall not be burnt/drilled nor lifting brackets welded to the sheet piles without the prior approval of the Engineer. All such modification shall be made good after use.

Wherever possible the same pile sections, lengths and steel grades shall be stored in separate stacks clearly marked/colour coded to avoid errors in placement.

### Pitching & Driving

The selection of the driving and extracting plant shall be made having due regard to the ground conditions and pile type.

The Engineer shall be notified of the contractor’s intention to pitch and drive piles at least 24 hours prior to commencement of the installation works. Prior to interlocking sheet piles the contractor shall ensure that the locks are undamaged clean and free from deleterious materials.

Pitch and drive techniques shall be permitted if the following criteria are met:

* The rig has sufficient height to adequately support the entire pile during driving.
* The driving will be relatively easy, without hard bands or obstructions which would dictate the requirement for full support afforded by panel driving techniques.
* The Contractor can satisfy the Engineer that the sheet pile structure can be built to conform to the specified tolerances for verticality and alignment.

In all cases the piles shall be guided and held in position during pitching and driving. All piles shall be fully interlocked without exception. Overlapping of piles will not be accepted as a substitute for interlocking piles.

Taper piles shall not be introduced to correct piles which have developed a lean, unless the approval of the Engineer is first obtained.

Piles which reach refusal before achieving the design penetration shall not be cut off without the approval of the Engineer. In difficult driving conditions a lead in excess of 1 m shall not be allowed to develop between the toe level of the pile being driven and the level of its neighbouring pile.

The contractor shall do all within his power/experience to avoid driving damage or declutching. The Engineer shall be notified immediately if any of these occur.

Percussive piling hammers shall be either freely suspended in which case they will have suitable leg guides/inserts in sound working order, or leader mounted in which case the leader must be of suitable rigidity and strength to keep the hammer stable during driving and moving operations. In all cases the hammer shall be held in position over the pile such that each blow is directed axially down the centreline of the pile/pair. (When driving high modulus units the centreline of the hammer blow shall be positioned as close to the centreline of the combined unit or between that position and the centreline of the beam unit).

The anvil block shall be of sufficient plan area to cover at least 90% of the pile or piles being driven and of sufficient thickness to adequately transfer the heaviest hammer blow evenly to the pile heads. The anvil shall be flat and level, without substantial wears such that the blow is transferred axially and distributed evenly over the pile head.

Where sheet piles are driven to a set to indicate vertical load carrying capacity this shall always be calibrated by maintained load testing on a representative sample of the piles. The set shall be recorded with a hammer of well defined input energy such as a gravity drop hammer or a hydraulic drop hammer. Where it is unavoidable to use hammers of less certain input energy, i.e. air hammers and diesel hammers, then the maximum losses must be used in the set calculation i.e. assuming approximately 30% hammer efficiency.

### Driving Tolerances

The following tolerances are suitable for general site practice for permanent structures. However more lenient limits may be applied if difficult driving conditions are encountered i.e. obstructions or the works are only temporary:

* Deviation perpendicular to theoretical line ±50mm.
* Deviation of verticality normal to and along the line of the piles, 1 in 100.
* Top of finished pile level ±20mm.

Deviation from these tolerances will not be acceptable without written agreement from the Engineer. Forcible correction will not be permitted.

The above tolerances are included for guidance purposes only and should be altered depending on site specific requirements

### Driving Records

The Contractor shall keep complete and accurate piling records. Two signed copies of these records shall be submitted to the Engineernot more than 48 hours from the date of the works detailed therein. The pile records shall always be submitted with sufficient time for the Engineer’s approval prior to the piles becoming inaccessible due to further operations.

The records shall contain the following information:

* Pile reference number (correlated to previously accepted works general arrangement drawing showing each pile position and reference).
* Pile type and steel grade.
* Pile length.
* Commencing surface level and final toe level.
* Depth driven, type of construction plant and times and dates when piles were driven.
* Where required the number of blows to drive each 250 mm over the last 2.5 m shall be recorded.
* Comments regarding unusual/ unexpected driving conditions (both harder, e.g. obstructions, or easier, i.e. increased penetration rates) should be included.
* Where changes in the pile length have occurred due to lengthening or cutting, all relevant information including off-cut length or extension length, reason for change and on what authority the change was made shall be included.

## 

# Fences and Landscaping

Prior to commencement of any landscaping work, the Contractor shall submit to the Engineerfor approval his detailed proposals for landscaping including the proposed species of grass, trees and shrubs.

## Fence and Gates

### Fences

Fencing shall be constructed where shown on the Drawings and approved by the Engineer.

All items of material for fencing shall be standard products of specialised manufacturers. Posts and struts shall be either reinforced concrete or galvanised steel sections. Timber posts shall not be used.

In areas where the ground has not already been graded during other earthworks operations, the fence shall generally follow the existing ground line. Minor irregularities shall be removed or filled by grading 60 cm on each side of the fence.

Fence shall consist of :

Prestressed concrete or galvanised and 2-coated steel pipe posts with a height of 2.0 m including barbed wire holders inclined inwards with a projected height of 0.5 m. Posts shall be anchored in foundations of a width/length 40 cm x 40 cm and a depth of at least 40 cm, filled with concrete class C20/25. Steel posts shall be closed at the top with plastic or cast zinc alloy caps. Posts shall be suitably braced during concreting to ensure that they remain in the correct line and level during placing of concrete and the concrete shall be cured for 3 days before any further work is done at the post.

* Normal posts with spacing not exceeding 3 m in straight lengths of fence.
* Straining posts to be installed to 20 m intervals and at changes in line or direction and supported by two diagonal struts. Sufficient straining wires, winding ratchets, joining clamps and other fittings required shall be provided for all end, corner and gate posts.
* Additional posts to connect the fence to gates and structures shall be provided.

Standard, galvanised and plastic coated wire mesh in a height of 2 m, sustainable connected and tensioned to the posts.

Three rows of galvanised and plastic coated 2 strand, 4 point barbed wire to be fixed to the cranked top section of the posts. Sufficient ratchet, winders and clamps are to be provided to assemble and to secure the barbed wire.

Fences shall be installed in accordance with the fence manufacturer’s drawings and written installation instruction, except as modified herein. Each line of fencing shall be erected so that it is plumb, taut, true to line and grade, and complete in all details. The outside face of the fabric shall be on the property line where the fence runs along the property boundary. [new]

### Gates

Access gates shall be made of:

a steel frame consisting in rectangular or round hollow sections of sufficient cross-sectional-area, width and height or diameter not less than 5 cm, wall thickness not less than 3 mm. The frame shall be 2.0 m in height.

filling rods placed vertically into the frame in a distance not less than 10 cm and consisting in rectangular or round hollow sections of sufficient cross-sectional-area, width and height or diameter not less than 3 cm, wall thickness not less than 2 mm.

The whole frame including filling rods shall be factory welded, hot-dip galvanised and 2-layer coated.

The tops of the gate shall be levelled with the tops of adjacent fencing (excluding barbed wire holders).

Man-gates shall be hinged single-entrance gates with a clearance of 1 m.

Car-gates shall be motor-driven mono-rail based sliding gates with a clearance of at least 6 m. Motor, gearbox and drive wheel / pinion shall conform to the requirements.

The gate shall be equipped with an automatic emergency stop mechanism to avoid persons to be shut between gate end and limit stop. Furthermore an additional emergency stop push button shall be installed. The gate shall be lockable with a key control switch.

Motor control shall be as follows:

Gate opens automatically for cars leaving the Plant by means of an inductive loop placed below the road surface in an appropriate distance from the gate. Gates closes automatically controlled by free adjustable timer.

Higher-ranking manual remote and key switch open-close control to be operated by the Security Staff.

Higher-ranking emergency stop.

The Contractor shall submit to the Engineer sufficient documents for approval of the gate system (gate, motor-drive, control).

Each man-gate shall be supplied with a padlock and three keys all to the Engineer’s approval.

## Landscaping

### Preparation of Ground

Where so required landscaping of the site shall be undertaken after the Contractor has completed all other earthworks apart from replacing top soil. The areas to be landscaped shall be brought to final ground levels less the depth required for top soil or other surfacing and all surplus material shall be disposed off site.

### Top Soil

The work includes transport of topsoil from temporary stockpiles on site, spreading and trimming.

Existing top soil stripped from the site and stored in heaps may be reused provided it has not become contaminated and is free of rubble and debris.

Where insufficient site top soil is available top soil shall be imported from an approved source. Samples shall be submitted to and be approved by the Engineerbefore landscaping work is commenced.

The topsoil shall be evenly spread and trimmed over embankments and filled to the slopes and levels as shown on approved Drawings. The depth after spreading and trimming shall be 20 cm measured perpendicular to the surface.

Where the upper layer of natural soil is poor in organic matter, it shall be improved to a minimum depth of 25 cm by adding either clay or sand or silt to create a loamy soil texture consisting of 40% sand (size >0.05 mm), 30% silt (size 0.05 -0.002 mm) and 30% clay (size <0.002 mm).

A shallow ripping will be required before adding clay or sand or silt which should be undermixed properly by using a disk harrow. If it should be necessary for topo­graphical reasons, levelling shall be carried out before mixing clay, sand or silt.

Tress shall be planted beforehand.

### Time for Planting

In programming the planting work the Contractor shall take due regard of the accepted seasons for planting. Should the time for completion be such that landscaping works would be carried out at a time when planting is inadvisable then the Contractor may apply to the Engineer for permission to postpone the planting until a more suitable time of the year.

Should this delay mean that the planting has to be carried out after the date of completion of the Works then the Contractor shall give satisfactory undertakings to carry out the outstanding landscaping during the Period of Maintenance.

### Leaching

Immediately prior to planting and the direction of the Engineer the Contractor shall irrigate areas for planting to leach out remaining traces of salt. Irrigation water shall be applied uniformly over the ground for 7 consecutive days at a rate of not less than 15 l/m² per day.

### Top Soil Dressing

Top soil ready to receive planting shall be given a dressing of chemical fertiliser or manure approved by the Engineerat a rate of 7.5 kg/m². After being spread uniformly on the surface the manure shall be thoroughly mixed into the top soil.

### Supply and Planting of Trees and Shrubs

Trees and shrubs shall not planted at locations where roots may destroy or infiltrate buried pipes or cables or where lapsed leaves may fall or blown into open tanks. Number, species and location of trees and shrubs shall be approved by the Engineer before planting.

Trees and shrubs shall be of the species proposed by the Contractor and approved by the Engineer and shall be of the best quality and free from disease. They shall be young stock or in the case of shrubs may be established seedlings or cuttings. All must be sufficiently mature to survive transplanting from the supply nursery.

The root systems of all plants shall be maintained intact in the soil in which they have been grown and may be supplied in containers.

All trees and shrubs and other plants shall be supplied by a nursery approved by the Engineer.

Prior to planting, holes for trees and shrubs shall be prepared and filled twice with water. Plants shall be watered in their containers so that the soil and the roots are kept in a moist condition. Plants shall then be removed from their containers and their root ball complete with soil set in place and the holes backfilled and the plants firmly trodden in.

Soil shall not be allowed to rise above the original container level and the ground level around the trunk or stem shall be set below adjacent ground to retain irrigation water.

All species of trees and shrubs where required shall be provided with supports during planting. These shall take the form of timber stakes of adequate strength driven into the ground adjacent to the trunk or stem without damage to roots. Wide hessian strips shall be used to tie the plant securely but not tightly to the support.

Where shrubs are to be planted in groups to provide ground cover, individual plants shall be spaced as follows:

|  |  |  |
| --- | --- | --- |
| **Size** | **Height** | **Spacing** |
| Small | less than 1 m | 50 - 60 cm |
| Medium | 1 to 2 m | 90 – 120 cm |
| Large | over 2 m | 180 cm |

### Support for Climbing Plants

Training wires shall be pegged to brickwork walling where required to support climbing plants. Wires shall be horizontal fixed to every four courses of brickwork with pegs at 1,500 mm maximum centres.

Climbing plants shall be secured to wire with sisal string as required.

### Supply and Planting of Grasses

Grass seed shall be any alternative species proposed by the Contractor and shall be tested and approved by the Engineer.

After sowing grass seeds, soil shall be rolled.

### Irrigation

After planting of native tree and shrub species they shall be irrigated regularly until hand over to the Engineer. The Contractor shall provide water for irrigation.

Grassed areas shall be irrigated immediately after planting and regularly thereafter until handing over. Watering of grass shall preferably be by night time sprinkler system. If watering is carried out during the daytime the area should be flooded.

### Maintenance

All new plants and grassing shall be maintained for not less than 12 months after planting. This shall take the form of irrigation, restaking, pruning, weeding, tilling, etc. to ensure sufficient growth is achieved by all plants up to hand over to the satisfaction of the Engineer.

Once grassed areas are sufficiently established they shall be kept cut or mown to provide a uniform depth growth. Edges of grassed areas shall be trimmed as necessary.

All new plants and grassed areas shall be protected to prevent damage from workmen, builders plant and equipment, goats and other animals, by the use of temporary fencing or other suitable means.

### Replacement

Any trees, shrubs or areas of grass which fail to show satisfactory growth or that wither and die shall be replaced by the Contractor.

The responsibility for the irrigation and maintenance of these replacement plants shall remain with the Contractor until such time as they exhibit satisfactory growth.

## 

# Building Works

## General

### Scope of Works

This Section covers the requirements for the construction of buildings and includes all building works, except earth and concrete works. The work required under this Section shall include all labour, materials, equipment, and all other appurtenant works required to complete all building works specified herein.

### Standards

The Contractor shall carry out the works described building works in accordance with the appropriate Local standards or equivalent standards.

### Approval of Materials and Workmanship

The supply of all materials and items shall be subject to the approval of the Engineer. The Contractor shall provide such samples as the Engineermay require in advance for the approval and, when approved, the quality of materials and workmanship shall be at least equal to the approved samples.

## Masonry

### Bricks

Bricks shall be either

* clay facing bricks or
* concrete block bricks

Brick that are manufactured locally with the quality shall correspond to the relevant Local standards. Bricks shall be hard, sound, square and clean with sharp, well defined arises.

The Contractor shall submit samples of each type of bricks used in the works and obtain the Engineer’s approval before placing orders with suppliers. Strength test certificates performed on the basis of appropriate standards shall also be submitted on request of the Engineer.

### Mortar

Sand

Sand shall be clean and sharp course grit, fresh water river or pit sand and shall be re-washed on site if the silt, loam or clay content exceeds the limits prescribed in the relevant standards. The sand shall be obtained from a source approved by the Engineer.

Cement

Cement shall be sulphate resisting Portland cement as specified in the relevant sections of this Specification. The source of cement is subject to the approval of the Engineer and shall not be changed without his prior approval.

Water

For the mixing of mortar and plaster the Contractor shall provide tap water, if not otherwise directed or approved by the Engineer.

Mortar Mix

Masonry mortar for setting bricks shall be mixed of 1 part cement to 4 parts sand or as otherwise directed or approved by the Engineer. Cement shall be added to the mix in an amount compatible with workability. Mortar constituents shall be measured by volume using clean gauge boxes.

Mortar shall be mixed in a mechanically operated mortar mixer for at least 3 minutes after all ingredients are in the drum.

Mortar shall be used within 2 hours after discharge from the mixer at normal temperatures. No mortar shall be used after the initial set has taken place. Reconstitution of mortar will not be permitted.

### Workmanship

All masonry shall be laid plumb and true to lines and built to the thickness and bond required. Masonry shall be carried up in a uniform manner. No portion shall be in raise more than 1 m above adjacent portions, except with the approval of the Engineer.

Sample panels of 1 m² size shall be prepared for each type of facing brickwork or blockwork, including jointing or pointing, and the Contractor shall not commence facework without the approval of the Engineer. Facework shall be kept clean during construction and until completion of the Works.

Under hot and dry weather conditions bricks shall be stacked on a hard standing level so as to prevent the absorption of water. Suitable shading shall be provided to prevent high temperatures within the brick stacks. Clay brickwork shall be kept wet to the minimum extent required to prevent mortar drying out prematurely.

Solid brick walls shall be laid in common bond with all joints filled solidly with mortar and backs fully purged to form solid masonry structure. Joints of walls to receive plaster shall be lightly raked to provide a bond for plaster. Control joints in brick walls shall be carried through the plaster. The joint shall not be plastered.

Freshly laid brickwork shall be protected during interruption through rain and at the completion of each day’s work.

Facework shall be kept clean during construction and until practical completion. Scaffold boards shall be kept clear of the building at night and during heavy rain. Rubbing to remove stains will not be permitted.

All bricks shall be wetted before being laid. Clay bricks shall not be used until completely cold from the kiln.

Facing bricks of varying colour shall be distributed evenly throughout the work so that no patches appear. Different deliveries, which vary in colour, shall be mixed to avoid horizontal stripes.

Walls which are to be fair face shall have selected bricks with perfect arises and flat surface structures and with faces in line.

### Miscellaneous

The Contractor shall build in or provide all miscellaneous items to be set in masonry including lintels, frames, reinforcing steel, electrical boxes, fixtures, sleeves, grilles, anchors and other miscellaneous items. All anchorage, attachments and bonding devices shall be completely covered with mortar.

### Cleaning

Masonry work to be exposed shall be thoroughly cleaned. Mortar smears and droppings on concrete block walls shall be dry before removal with a trowel. Masonry work may be cleaned using a mild muriatic acid solution.

## Plastering

### Mortar

Mortar for plastering shall be as specified in Sub-clause 1.23.2. (Mortar). Plaster applied to external wall faces shall contain a waterproofing agent. The water proofing agent shall be a mass product of a repudiated manufacturer and shall be approved by the Engineer.

Mortar for dash coats shall be composed of 1 part Portland cement and 1.5 parts of sand.

### Workmanship

Plain finished plastering shall be carried out in two or three coats. Three coat work shall be carried out on metal latching and on other backgrounds which the Engineer determines by inspection to be too uneven to permit two coat work.

Tyrolean finish shall be used on external surfaces only.

If plaster is to be applied to smooth surfaces, a dash coat shall be applied as a bonding surface. [new]

The plaster coats shall be applied according to the thicknesses given below, whereby additional thickness, which will be required due to unevenness in the masonry surface, is not included:

Location: Ceiling Interior wall Exterior wall

Thickness of first coat: 10 mm 10 mm 15 mm

Thickness of intermediate coat: - 6 mm 10 mm

Thickness of finish coat: 10 mm 4 mm 5 mm

Total thickness: 25 mm 20 mm 30 mm

Where plastering is to be applied to surface of concrete or blockwork such surfaces shall be treated by means approved by the Engineer to provide a mechanical key for the rendering and shall be dumped by brushing or spraying with water.

Where dissimilar wall backgrounds meet to form a continuous surface a 150 mm wide strip of galvanised steel mesh wire shall be fixed over the joint between the dissimilar surface before the first undercoat is applied. Mesh wire edge profiles shall be installed to protect edges.

Surfaces shall be cleaned of all residual mould oil dust loose particles and other deleterious material before rendering work is begun.

Each undercoat shall be combed or scratched to provide a key for subsequent coats as soon as undercoat has set firm.

Particular care shall be taken to cure newly applied rendering as specified herein for concrete. Each coat shall be allowed to dry completely before the next coat is applied. The finishing coat shall have a wood float finish to true planes and regular curves and to an even surface. Arises shall be rounded and in true alignment and a hollow fillet shall be run at internal angles.

Where fixtures have to be installed prior to plastering they shall adequately be protected from damage during plastering. The dash coat shall be applied with a whisk broom or fibre brush and be kept moist for 48 hours before the first coat is applied to the dash coat.

Completion of work includes curing (moisturising for at least 3 days) and removal of deficiencies (at the Contractor’s expense). Upon completion of the work, all plaster surfaces shall be cleaned and all rubbish, debris and excess material and equipment shall be removed.

All surfaces shall be true to line, level, plumb and all junctions, angles and arises truly scare.

## Floor Screed

Screed in buildings shall be applied to a thickness of at least 5 cm, surface shall be plane level.

Before screed is applied onto concrete slabs all laitance shall be removed and the concrete slab shall be cleaned from all loose material, dust and dirt by thorough washing with water.

The characteristics of the ready screed shall be

* Density: 2 t/m3
* Compression strength after 28 days: >50 MPa
* Tensile strength after 28 days: >10 MPa

The screed mix shall be prepared from appropriate cement, water and aggregates and shall be thoroughly and efficiently be mixed dry by mechanical means until a uniform distribution is obtained prior to adding the water. The water content shall be kept as low as it is necessary to allow for sufficient workability for laying and compacting. Where only small quantities are required, mixing might be carried out by hand on clean watertight surface with the approval of the Engineer.

The screed mix shall be placed between forms and worked around orifices, duct covers, manhole covers, gutters, balustrade standards, pipes, etc., and set true to level within ±3 mm, and shall be fully compacted by means of a screed board avoiding laitance is not brought to the surface. The screed wearing course shall be tamped with a wood float and trowelled with a steel trowel to produce a smooth finish.

Screed forming the final floor shall be applied onto the screed base course and shall be

* self-levelling
* resistant to gasoline, oil and solvents
* highly wear resistant qualified for any kind of mechanical stress
* waterproof, qualified also in wet rooms
* antislip even in cases of oil spills and in wet rooms
* not electro-statically chargeable

All edge joints of floor screed shall be simple butt joints without filler. Screed laid over construction joints in concrete shall be separated by 10 mm impregnated oakum strips or the like.

Floor screed, when laid, shall be free of all defects and any work which shows signs of bond failure, hollow patches, crazing, cracking or any other defects will not be accepted and shall be removed and replaced with acceptable work by the Contractor.

The extent of the work to be removed and the method to be used in the removal and replacement of this work shall be to the approval of the Engineer.

The Engineerbefore further work shall approve all surfaces.

## Internal Flooring

All materials and structural components shall be used only with the approval of the Engineer.

Before starting the work, the Contractor shall ascertain the Engineer's selection of patterns and colours and the Contractor shall furnish the Engineer with duplicate samples of the patterns and colours of the materials selected by the Engineer.

### Paving

Paving shall be either natural stone (marble, sandstone, granite, limestone) or ceramic tiles (for kitchens, toilets, showers, etc.).

Natural stone tiles shall be sound, durable, hard, and have such properties that they will not disintegrate from the action of handling and placing. The density of stones shall be not less than 2.2 t/m³.

Ceramic floor tiles shall be of best quality available on the local market.

Tiles in generally shall be even and regular in size, true to plane, free of warps, cracks, crazing, discoloration, stains or defects.

Paving shall be of approved co-ordinated dimensions. The kind, quality and colour shall be approved by the Engineer. Therefore the Contractor shall submit some samples to the Engineer before ordering the tiles.

The tiles shall be bedded and pointed in 1:3 Portland cement-sand mortar. Broken or scratched tiles shall not be used.

A tile skirting, with the same kind of tiles, shall be provided for all areas where the floor is tiled.

Flooring tiles shall be laid evenly with joints of 3 mm. Where gullies and/or drainage facilities are provided, the tiles shall be laid with a slight slope towards these outlets to ensure good run-off of surface water. All joints shall be completely filled with mortar.

Tile work on foundation blocks, supports, etc., for the mechanical and electrical equipment shall be carried out after installation of the equipment.

Tiling shall be free of any defects and any work that shows signs of bond failures, hollow patches, misalignment, cracking or any other defect. Defective work will not be accepted and shall be removed and replaced by acceptable work.

### Computer Room Flooring

Computer room flooring, where applicable, shall be a proprietary modular flooring system in which square floor panels are fitted into a gridded support overlying a cavity containing power and telemetry cables. The removable panels shall not be less than 50 cm or more than 70 cm square form, and shall be non-conducting and carpeted with anti-static material.

The grid system and its supports shall be of approved materials, and shall be designed such that the deflection of the floor under personnel loading does not exceed 1 mm at any point.

The Contractor shall, if required, hand over to the Engineer two special tools for lifting computer flooring panels.

### PVC Flooring

PVC flooring shall comply with the respective Local Standards and shall be temperature resistant, waterproof, abrasion resistant, flameproof, pig­ment or colour proof to light, evenly coloured throughout, resistant to chemicals, fats, acids and alkalines, odourless, easily laid and flexible, non-porous and slip proof.

All adhesives shall have suitable properties to ensure a firm and durable bond. They must not adversely affect either the flooring nor the underlays or the base and shall be odourless once applied.

All fillers and levelling compounds shall have a firm and durable bond to the base, provide a good bonding surface for the adhesive and be of suitable property so as to give an adequate support to the covering. They must have no adverse effect on base, adhesive, underlay, or covering.

PVC tiles shall be laid perfectly true and even fixed with approved adhesive edges closely butt jointed. Sit on skirtings shall be fixed with approved adhesive and cut as necessary to fit closely into position.

Skirtings to PVC floors shall be in timber, counter sunk screwed to rough grounds set into walling and pelleted in grain.

### Carpeting

Carpets shall comply with the classification and terminology laid down in the respective Local Standards. Carpets shall be made from 100% continuous filament nylon approved man-made fibre on man-made backing, and shall be broadloom with tufted tightly twist pile construction. Pile height shall not be more than 5 mm with not less than 3 rows per cm, 19 tufts per cm2 and weight not less than 3.25 kg/m2.

Carpet cushion shall comply with the following requirements:

* walking shock absorbing
* moisture penetration resisting
* noise reducing
* fire retardant
* toxicity tested

Samples of carpet and cushion shall be laid for approval of the Engineer.

Nosings at all steps and changes of level shall be protected with aluminium extrusions.

Skirtings to carpeted floors shall be in timber, counter sunk screwed to rough grounds set into walling and pelleted in grain.

### Preparation of Surfaces

The surfaces must be cleaned prior to flooring. The base for covering to be placed without underlay shall be smoothed with filler compound. In the case of major unevenness a suitable levelling compound shall be used.

Any filler or levelling compound shall be applied so that it will bond firmly and durably to the base, will not crack and will adequately withstand pressure. Any screeds such as magnesia and anhydride screed to which the filler or levelling compound will not sufficiently bond, shall receive a priming coat.

### Workmanship

Floorings shall be placed without underlays unless otherwise specified. The courses shall be laid towards the main window wall, in halls and corridors, however, in longitudinal direction, unless otherwise specified.

Deviations in colour which are not of minor importance and not due to the flooring pattern shall not be allowed if marring the overall appearance of the flooring. Courses with pattern repeats shall be laid so as to suit these.

Where courses run towards doors, recesses and the like, they shall be laid so to cover also the floor areas such door openings, recesses etc. Strips of slabs may be used as coverings of such floor areas.

### Protection

All finished surfaces shall be properly protected until completion of the contract. ~~Terrazzo~~ Tile and in-situ flooring shall be protected with a layer of clean sawdust. PVC tile floors and carpets shall be protected with polythene sheeting.

## Internal Wall-Tiling

### Materials

In general, tiles and flags shall be of best quality available on the local market. Where tiles and flags are not standardised, the quality features shall satisfy the standard commercial requirements (top surface, parallelism of edges, colour, and water absorption). All floor and wall tiles shall be from the same batch.

Glazed ceramic wall tiles shall be in the colour selected by the Engineer, true to shape, flat, free from flaws, cracks and crazing, uniform in colour, keyed on the back The tiles shall be of a suitable type, size, colour and acid resistance, where required (i.e. laboratory).

Cement based adhesives and other adhesives shall be subject to the approval of the Engineerand mixed and used strictly in accordance to the manufacturer’s printed instruction. Mortar materials and adhesives shall not alter the top surface of the tiles.

### Placing of Tiles

All cutting to tiles shall be fair cutting using a tile cutter.

In interior finishing works all tiles, flags or mosaic shall only be set and laid before the fixing of windows and door frames and trims, and after stop rails, plumbing in­stallations and the application of plaster.

Wall faces shall be cleaned and primed according to the manufacturer’s instructions and the adhesive shall be applied by the notched trowel technique and trowelled over the area to receive tiles in 4 mm thick­ness.

All tiles, flags and mosaic shall be set or laid plumb, in true alignment and horizontal or at the slope specified, without any projections, with regard to any specified reference or level lines. In wall coverings, projections shall be allowed only to the extent imposed by the particular type of tile or flag specified.

The external angles and side and top edges shall be formed with rounded edge tiles. At intersections, returned rounded edge tiles shall be used.

## Wall Painting

The surface of the plastered walls and ceilings shall be painted with a washable and, for outer walls, weatherproof wall paint. The paint to be used shall be the best quality plastic emulsion paint available in Montenegro. The colour will be selected by the Engineer.

Walls and ceiling shall be cleaned from plaster splashes etc. before painting.

All surface fittings, ironmongery, etc., except hinges shall be removed before painting and re-fixed on completion. They shall be entirely free of any droppings, paint smears and blemishes.

Ready floors and window frames shall be protected against splashing by covering with plastic sheets. Wall may be spread with spray gun. In any case the paint has to be spread in accordance to the manufacturer’s instruction.

Inner walls shall be painted in 2 layers; outer walls shall be painted in 3 layers. Each layer shall be allowed to dry completely before the next layer is applied. The paint has to be spread evenly in an equal layer thickness.

## Roof Construction

All roofs shall be sloped with a minimum slope of ≥ 30° angle ≤ 48 °. Roof construction shall be erected above concrete roof slabs.

Trusses shall be from timber and of rafter- or purlin-type with form boards, lathing, and counter-lathing.

Roof shall be ventilated below rafters and below roof cover. Roof shall be covered by roof tiles. Roofs shall be accessible either by closable openings in the ceiling slab below the roof or by openings on top of the roof.

### Timber Truss Works

The Contractor shall submit to the Engineer drawings showing the roof construction, showing purlins, rafters, supports, struts, form boards, laths, counterlaths, etc. and connection systems. The whole roof construction shall be designed to carry all dead load, wind load, etc., to allow for proper ventilation and to avoid wood to be constantly in contact with rainwater.

A high standard of workmanship and materials shall be achieved in the works. The completed timber work shall be durable, well finished and designed and constructed.

Workmen employed in the manufacture and installation of timberwork shall be experienced carpenters.

Timber shall be of best quality, sound, in good condition, reasonably free from shakes and free from loose dead knots, insect attack, decay, twisting and warping. Timber shall be properly seasoned to suit the purpose for which it is intended. Where timber is prescribed as “selected“ it shall be free from knots.

Softwood shall be either redwood, specially selected from the best unsorted and joinery quality or Douglas fir of selected merchantable quality or better.

Hardwood shall be selected and of best quality; pinhole borers shall particularly check it for infestation.

All plywood, chipboard or materials incorporating chipboard shall not be used in the works, except with express permission by the Engineer in writing.

Before commencing work, the Contractor shall submit samples of all types of timber to be used in the works for the approval of the Engineer. Timber, or carpentry and joinery units of which the material on delivery to the site does not conform to the standard of approved samples will be rejected and replaced by the Contractor at his own expense.

The carpenter shall perform all necessary mortising, grooving, matching, housing, and all other works for correct jointing. He shall also provide all metal plates, screws and other fixings that may be specified or necessary for the pro­per execution of the works and he shall carry out all works necessary for the proper construction of all framings, linings etc. and for their support and fixing in the works.

No nails shall be used to assemble or fix hardwood or major supports. Screws used in exposed locations and/or for hardwood shall be brass and complete with brass surrounds.

### Roof Thermal Insulation

Roof thermal insulation shall be accomplished by insulating the concrete roof slab below the roof structure.

The Contractor shall submit samples and references to the Engineer for his approval of the materials he intends to use before ordering these materials.

The concrete roof slab shall be insulated as follows:

Screed layer as specified in Sub-clause 1.23.4.

Insulation with sheets of mineral wool or material with similar insulation quality as approved by the Engineer

### Roof Cover

On top of the form boards 2 layers of bituminous membranes 1.5 mm thick shall be used for water insulation. The membrane shall be continuous and shall be watertightly dressed and bonded under flashings for i.e. chimneys, dormers etc. or other structures penetrating the membrane and shall be dressed and bonded into gutters.

Roof shall be sealed finally with roofing tiles to be approved by the Engineer.

The roof surfaces shall be uniform, compact and free from debris.

### Flashings and Gutters

Flashings shall be formed out of 0.8 mm aluminium with natural mill finish. Accessories such as hooks, nails, screws and clamps shall be of the same material and alloy. The aluminium shall be carefully bent using a slightly rounded former so as to avoid surface cracking. Where surface fixing is required, the sheet shall be pre-drilled and fixed with inoxidisable screws to proprietary fixings or hardwood grounds let into the surface of the base concrete or brick work.

### Vent Pipes

Vent pipes shall extend through the roof and terminate at an efficient height and as may be agreed by the Engineer. The vent pipe passengers through roofs shall be made watertight and shall be provided with a PVC de-aeration caps on the roof. Where necessary, PVC-gratings shall be provided at the ceilings. [G34.11, last paragraph]

### Roofing Tiles

Precast cement roofing tiles shall be formed with a minimum 10 mm facing of one part white cement and three parts of sand, set on a backing of sulphate resistant cement mortar with a minimum cement content of 300 kg/m³.

### Rainwater Drainage

Gutters shall have a radius of not less than 5 cm and shall drain from the top interface between the waterproof membrane.

Gutter shall have sufficient slope to drain to the rainwater outlets. Downpipes shall be made of tinplate with a minimum diameter of 10 cm.

## Doors and Windows General

Doors and windows shall be of good quality and robust and shall be to the dimensions and details shown on the approved Contractor's Drawings.

The Contractor shall submit details of manufacture including sections of the frame members and no orders shall be placed until such details have been approved by the Engineer.

All doors or windows of the same material shall be from one manufacturer only.

Doors and windows shall be such that glazing or re-glazing on site is possible without the need to remove the outer frame from the structure of the building.

Flashings, weather bars, drips, storm moulds, caulking and pointing shall be installed so that water is prevented from penetrating the building between the frame of external doors or windows and the building structure under the prevailing service conditions, including normal structural movement of the building.

For external doors and windows flashings and weatherings shall be used which are corrosion resistant, compatible with the other materials in the installation, and coated with a non staining compound where necessary.

### Construction

Joints shall be made accurately fitted tight so that neither fasteners nor fixing devices such as pins, screws, adhesives and pressure indentations are visible on exposed surfaces.

Moving parts shall operate freely and smoothly, without binding or sticking, at correct tensions or operating forces and that they are lubricated where appropriate.

Doors and windows shall be installed so that the frames are

* plumb, level, straight and true within acceptable building tolerances;
* are adequately fixed or anchored to the building structure;
* and will not carry any building loads, including loads caused by structural deflection or shortening.

Mouldings, architraves, reveal linings, and other internal trim shall be provided using materials and finishes matching the frames, to make neat and clean junctions between the frame and the adjoining building surface.

### Hardware

The Contractor shall furnish and install all finish hardware to complete the work as specified.

The Contractor shall submit samples of all hardware to the Engineerfor approval.

All hardware shall have the required screws, bolts and fastenings necessary for proper installation, wrapped in paper and packed in the same package as the hardware. Each package shall be legibly labelled, indicating that portion of the work for which it is intended.

All hardware shall be of the best grade, entirely free from imperfections in manu­facture and finish.

Quantities, weight and sizes specified herein are the minimum that will be acceptable.

Finish of all hardware shall be dull stainless steel unless otherwise noted.

Unless otherwise indicated, all hardware installation and hanging shall be done at the site.

Upon completion of the hardware installation, all items shall be inspected for proper operation. All work shall be protected and any damage or incorrectness shall be repaired.

Hardware shall not be fitted until the latest time in the Contract.

### Frames

Door supporting frames shall be of **U-form, window supporting frames shall be of -form.**

In brick openings supporting frames shall be fixed and bedded in mortar, PVC frames shall be fixed with steel wedges and bedded in mortar.

In concrete openings, supporting frames shall be connected to the concrete walls using chemical anchors.

Steel supporting frames for steel or aluminium doors and windows shall not be used as centring for brickwork or to support a lintel.

Steel supporting frames shall be formed from 1.5 mm thick, hot-dip galvanised rectangular hollow sections of sufficient cross-sectional-area, **full welded at joints (flush joint). The frames shall be equipped with welded laps, each lap with one bolt hole. In case of connection aluminium blind frames to steel supporting frames, provision shall be made to avoid contact corrosion.**

### Jointing, Pointing, Sealants

Jointing and pointing materials, including sealants, mastic’s, primers, gaskets and compressible fillers of types shall be compatible when used together and non staining to finished surfaces. Bituminous materials on absorbent surfaces shall not be used.

Glass and perimeter seals for doors and windows shall be made of EPDM with a magnetic tape insert. The hinge side shall be constructed so as to avoid pinching or other distortion of the seal from opening and closing of the door or window.

### Doors

All doors shall be flush doors. Clearance of external doors for persons shall be 90 cm x 200 cm. Clearance of internal doors for persons shall be 80 cm x 190 cm.

Exteriors doors and doors in air conditioned areas shall be weather-stripped.

**External doors shall be in generally vacuum double glazed in 4 +4 mm thick bonze solar control thermal glass.**

**Internal doors shall be in generally single glazed in 6 mm thick Georgian wired plate glass, or approved equivalent.**

### Doors Hardware

All door hardware shall be of stainless steel unless other specified.

Timber door sets shall be equipped with butt hinges in housings equal in depth to the thickness of the hinge leaf (except for hinges designed for mounting without housing), and fixed with countersunk screws. Steel frames shall be equipped with steel hinges fixed with metal thread screws. Aluminium frames shall be equipped with stainless steel hinges, fixed to the frame with stainless steel screws galvanically insulated. Hinges shall be adjustable to stay slightly ajar.

Not less than 3 hinges per door shall be applied. For doors with clearance greater than 2 m2, the number of hinges shall be as per static calculation.

Leaves shall be equipped with fixed, recessed hinge pockets **in number fitting to the frame.**

All external and office doors as well as the doors for laboratory and control room shall be fitted with tabular 5 level cylinder security locks incorporating separate dead bolts. Passage doors shall have no lock. Toilet cabin doors shall have a bolt on inside. All other doors shall have a normal lock.

All security locks in all buildings shall receive master keys. Three keys for each security lock shall be delivered. For normal locks each two keys shall be delivered.

All keys shall be clearly labelled with metal or hardboard tags size approximately 50 x 20 securely fixed to the keys and handed over to the Engineer.

All external doors as well as toilet cabin doors shall have a door latch inside and a door knob outside. All other lockable doors shall have door latches in- and outside. Passage doors shall have door handles on both sides.

Door closers shall be of heavy duty type and installed on all external doors on the inside for top installation for either right or left hands operation.

Door stops shall be floor or wall mounted type with rubber cover.

Emergency doors where shown on the Drawings or instructed by the Engineer shall be fitted with an approved panic bolt to the inside of the doors and the doors shall be designed to open outwards.

### Door Bottoms

Door bottoms for external doors shall be full mortised type with tubular neoprene and glass fibre core and shall close the entire gap between the door and the floor. Door bottoms shall ensure a continuous, positive, reliable seal at the floor with minimum friction, drag, and roll of the assembly on the floor.

### Steel Door Frames

Frames shall be fabricated from **at least 3** mm thick steel with the corners mitred, welded, and ground smooth. Strike, hinge, and other hardware reinforcement shall be of not less than 5 mm thick steel. The frame shall be provided with welded floor anchors at each jamb, and with a minimum of 3 wall anchors per jamb. Frames shall be set plumb and square in a true plane, and be securely anchored to the adjoining construction. Steel shims shall be provided and shall be set tight and rigidly attached between frame anchors and structure.

All parts shall be hot dip galvanised and shall receive thermoset powder coating.

### Timber Door Leaves

Timber door leaves shall have a minimum thickness of 40 mm and shall be faced both sides with hardwood veneered faces. The core shall be con­structed of longitudinal laminations of precision planed timber, butt jointed and glued with resin based adhesive under hydraulic pressure. All edges shall be bevelled and lipid with hardwood tongued into the edge of the door.

Hardwood doors shall be constructed out of teak or similar approved hardwood. Where required, the doors shall be glazed with 6 mm glass, fixed with hardwood glazing stops.

### Steel Doors Leaves

Steel doors leaves shall be of full flush design with no visible seams. **Steel door leaves shall consist in a corner frame formed from at least** 1.0 mm thick, hot-dip galvanised rectangular hollow sections of sufficient cross-sectional-area, **full welded at joints (flush joint) and** two 1.0 mm thick sheet metal leaf faces internally reinforced with **- or U-profiles welded in place to the inside of the leaf faces in sufficient number. The leaf cavity shall be filled with insulating material if necessary.** Tops of exterior doors shall be provided with flush, water and weather tight, top enclosures.

Leaves shall be rigid and neat in appearance, and shall be free from warpage or buckle. **Total thickness of leave shall be not less than 40 mm. Leave shall be rebated on 3 sides.**

Glazing stops shall be formed from 1 mm thick steel sheet and shall be non removable on outside of exterior doors and shall be removable (screw-applied ) on inside of exterior doors and internal doors.

All parts shall be hot dip galvanised and shall receive thermoset powder coating.

### Aluminium Doors

The main elements of aluminium solid section outer frame shall be not less than 2.0 mm thick. The thickness of all other structural elements of the sections shall be at minimum tolerance not less than 1.2 mm.

Joints in frames shall be made neatly and accurately either by welding or by mechanical means (e.g. cleating and screwing) and may have flush stepped or lapped surfaces. Welded joints shall be cleaned off smooth on the surfaces which are exposed when the window or door is in closed position or where they come into contact with glazing.

Hinges shall be either of suitable corrosion resistant materials or if not compatible with aluminium shall be separated from the aluminium by the materials that are compatible with it. Materials or finishes which are not compatible with aluminium shall not be used unless they are satisfactorily separate from the aluminium by materials that are compatible with it. Screws, nuts, bolts, washers and other fastenings shall be of stainless steel or aluminium.

**Door leaves shall consist in a corner frame formed from at least** 1.0 mm thick, rectangular hollow sections of sufficient cross-sectional-area **and** two 1.0 mm thick sheet metal leaf faces braced with **internal - or U-profiles welded to the inside of the leaf faces in sufficient number.** Weather-stripping sheets and glazing stops shall have a thickness of at least 0.8 mm.

All aluminium parts shall be finished satin matt and anodised.

Weather-stripping shall

be made from materials known to be compatible with aluminium,

not shrink or warp nor adhere to sliding surfaces or closing surfaces,

not promote corrosion when in contact with the aluminium alloy used, and

be resistant to deterioration by weathering.

External doors and frames shall be thermal blistered and finished externally in anodised aluminium with a bronze tone that matches the windows.

### Windows

All windows shall be pivot type window (tilt and turn). Both opening modes shall be controlled with the same lever handle.

**Windows shall be in generally vacuum double glazed in 4 +4 mm thick bonze solar control thermal glass.** Windows of toilets and showers shall be frosted.

All windows shall be provided by 3 cm thick marble sills.

All windows in this section of the Technical Requirements shall equal or exceed the following performance requirements: There shall be no water leakage when tested at 330 mm water gauge and air filtration shall be less than 12 m/h/m when tested at 40 mm water gauge.

### Hardware

All hardware shall be supplied and fixed by the manufacturer and shall match the finish of the surfaces of the units and shall be replaceable without removing the outer frame from the structure. Fasteners shall be designed so that they cannot be released from the outside by the insertion of a thin blade or other simple tool.

Windows indicated to be pivot type shall be furnished with a pair of window fittings (friction stays), a window pull and one barrel bolt lock. Window fittings shall be of stainless steel. Window pull shall be 2.5 x 10 cm with 4 screws and barrel bolts 10 cm long, 6 mm bolt.

### Aluminium Windows

Windows shall be of the thermal blistered double insulated type and shall be glazed in brown tinned glass to the approval of the Engineer.

All aluminium surfaces in contact with block work, concrete render or other alkaline materials shall be coated with two coats of black bitumen solution or similar approved protective coating. All unit surfaces, which will be visible when the window is fixed in position, shall be protected after manufacture by low tack tape or other suitable means capable of being removed after installation of the window to leave clean undamaged anodised surfaces.

### PVC Windows

The main frame shall be of at least 80 mm extruded rigid PVC with integral nailing flange, mitred corners, fusion welded. The frame shall have structural cavities and shall be steel reinforced to avoid warp, twist, sag or bow.

Windows shall be made with a co-extruded double gasket seal forming an integral part of the entire unit and not subject to shrink, crack or pull away.

Finish type shall be standard white. Weather stripping shall be of dual santoprene fin gaskets.

## Suspended Ceilings

Suspended ceilings shall be of the lay-in metal suspension system type.

Ceiling tiles shall be mineral fibre pre-painted smooth finish tiles, sized 600 x 600 x 20 mm with square edges and be laid into galvanised steel tee suspension grid. Additional support shall be provided by galvanised pressed steel channel sections at 1,200 mm centres set at right angles and clipped to primary tees and suspended from structural ceiling by wire or steel angle suspension members, also at 1,200 mm centres.

Edge trim angles shall be fixed to perimeter walls. The exposed faces of suspension tees and edge trim shall be pre-painted.

All necessary couplings and clips shall be provided.

Openings shall be formed in ceilings to accommodate air conditioning grills, where applicable, and recessed light fittings. 600 x 600 mm tile sized galvanised steel hinged access panels and frames shall be provided in ceilings as required for servicing mechanical and electrical equipment in the ceiling void. The panels shall be finished with matching tiles.

Movement joints shall be provided in suspended ceilings where required. The ceiling shall end on either side of the joint at a steel tee. A strip of pre-painted galvanised steel sheet shall be loose laid in the suspension grid and access the joint.

Where suspended ceilings change level, or abut windows and louvers, bulkheads shall be formed. These shall either be constructed from steel angle frames filled with plasterboard or dismountable partitioning construction.

Suspended ceilings shall be installed after wall finishes have been applied.

## Sanitary Systems

The work covered under this section comprises the providing of all labour, materials, equipment, accessories, services and tests, necessary and requisite for a complete and adequate sanitary system, such as:

* Drainage and vent pipe system
* Sewers and sewage disposal system, including connections
* Rainwater system
* Potable water pipework between buildings
* Sanitary fixtures
* Hot and cold water plumbing

Also included are the following items:

* All work of a civil nature, such as placing of pipe sleeves through floors and roofs for the passage of pipes at the time the concrete is poured, hangers and supports, excavations and backfill, manhole with covers, inspection pits, etc.
* Protection and cleaning
* Testing
* Miscellaneous.
* General

All materials and equipment provided by the Contractor shall be new and of the various qualities as required by these Technical Requirements.

All workmanship shall be of the highest standard and to the satisfaction of the Engineer. The sanitary system shall be installed in accordance with the relevant Local Standards unless otherwise ordered by the Engineer.

The Contractor shall submit full details, together with Drawings, of his proposals for approval of the Engineer before commencing the work and shall carry out all tests and inspections of the finished work as may be considered necessary by the Engineer.

The word ”complete” whenever used in these TA shall mean, in addition to the major items of plant, all incidental sundry components necessary for the complete operation of the installation, whether or not these components are mentioned in detail. The word ”piping” in these Technical Requirements shall mean the inclusion of all pipes, fittings, nipples, valves, and all required accessories, supports, anchors, guides, etc., for a complete safe and operational network.

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### Pipes and Fittings

The materials to be used for soil, wastewater, rainwater and ventilating pipes, including fittings, within the building shall be of PVC, PP, PE or GRP according to the relevant standards. Soil and waste piping for the drainage system outside the building shall be of concrete.

### Joints and Connections

Joints and connections in the sanitary system shall be gastight and watertight for the pressure required by test. Leaky joints shall be remade by using new materials. Joints in galvanised steel pipes shall be made by threading. Welding and bending are strictly prohibited on galvanised pipes.

Joints in plastic pipes shall be made with factory pre-installed rubber seal gaskets and shall be carried out according to manufacturer’s recommendations.

### Unions

All pipes shall be provided with unions at adequate intervals to permit easy disassembly for alternations and repairs.

Unions shall be provided near valves and equipment, which need to be taken out for servicing or repairs.

The unions shall be of material corresponding to the pipes in which they are installed, and of the same weights and rating.

### Hangers, Spacing and Supports

Piping shall be installed without undue strains and stresses and provisions shall be made for expansion, contraction and structural settlement. A sufficient number of horizontal and vertical supports shall be provided at proper intervals.

### Manholes and Inspection Pits

Manholes shall be provided at suitable locations and additionally where ordered by the Engineer.

The dimensions of the manholes or inspection pits shall be approved by the Engineer. All manholes shall be provided with cast-iron covers according to these ER.

### Sleeves

The Contractor shall furnish and install all sleeves to be built in for the passage of sanitary pipes through structures.

The Contractor shall co-ordinate placing of the necessary sleeves, of the appropriate sizes for his requirements, at the time the concrete is being poured. It is strictly prohibited to break or bore through reinforced concrete beams for the passage of pipe unless prior approval is obtained.

Pipe sleeves shall be of adequate size to allow free movement of pipes due to expansion and contraction, whether bare or insulated. Sleeves for sanitary pipes shall be PVC.

Pipe sleeves shall be finish flush with walls and shall project at least 3 cm above floors and approximately 15 cm above roofs or as otherwise agreed by the Engineer.

After the installation of pipes, the Contractor shall caulk the space between pipe and sleeve with an approved product to prevent the passage of air and vermin. The caulking shall be made in such a manner as to prevent it from coming off with pipe expansion or contraction.

### Protection and Cleaning

The inside of all pipes, valves, etc. shall be clean and free from dirt or other objectionable matters when erected. All lines shall be blown before placing in service. If necessary, all openings in the piping shall be closed during construction in order to keep the lines free from dirt, etc.

### Floor Drains

Floor drains shall have PVC/PP or SST traps and a minimum water seal of 7.5 cm and shall be provided with adjustable and removable PVC/SST strainers. The open area of strainer shall be at least two-thirds of the cross-sectional area of the drain line to which it connects.

### Installation of Pipes

Pipes passing through walls shall be protected from breakage. A soil or waste pipe passing through a foundation wall shall be fitted into a PVC sleeve pipe cast in the concrete and furnished with sockets at both ends.

Where it is required to cut plastic pipes it shall be done by a suitable pipe cutter so as to leave a clean and square end to the axis of the pipe.

### Inspection, Storage and Connections

All pipes shall be thoroughly inspected prior to laying and any suspected cracks or damaged material shall be rejected. The pipes shall be stacked horizontally during storage and the sockets must be prevented from resting on the ground. All connections shall be made watertight and gastight. Where vent pipes connect to a horizontal soil or waste pipe the vent shall be taken off above the centre-line of the pipe, and the vent pipe shall rise vertically.

No work of breaking into an existing public sewer and forming a connection shall be carried out without prior approval of the Engineer.

If any bedding or protection is removed to make a connection to a sewer or drain, the damage shall be made good.

Connections to sewers shall be made at existing manholes.

### Cold Water Pipes and Valves

The Contractor shall obtain the Engineer’s approval to his proposal for the potable water distribution system on the site.

Cold water main pipes inside buildings shall be NP 16 threaded galvanised steel. All precautions shall be taken to protect water supply and distribution pipes against contamination from the sanitary system.

Concealed pipes shall be installed in such a way as to permit easy access for maintenance. This applies particularly to valve locations.

All valves shall be fixed in neatly arranged vertical lines, and adequately pitched horizontal lines to allow the system to be properly vented and drained. Air pockets, traps and sags shall be carefully avoided. Pipes shall not be welded.

Gate valves shall be provided on all main and branch pipes for isolating sections of piping for maintenance. Each sanitary fixture shall be provided with a stop valve for washer replacement. The stop valve shall match the trim provided with the fixture.

### Hot Water Boilers

Small Electric Boilers

Small electric boilers shall be installed where low hot water consumption is expected. Small electric boilers shall comply with the following specifications:

* pressureless internal tank with a volume of 10 l
* energy-saving PU foam insulation
* white plastic case
* variable temperature control up to 80°C
* performance monitoring lamp

Large Electric Boilers

Large electric boilers shall be installed where high hot water consumption is expected. Large electric boilers shall comply with the following specifications:

* internal enamelled tank, working pressure 0.6 MPa, including protective anode, with a volume of at least 200 l or more
* energy-saving PU insulation at least 50 mm thick
* exchangeable electric heating system (discretionary heating-up time) consisting of an appropriate number of high-quality tubular radiators corrosion protected and mounted on a flange plate
* separate probe protecting tube for the control of the central heating furnace
* variable temperature control up to 85°C
* energy-saving button at 65°C
* performance monitoring lamp
* integrated dial thermometer
* suitable for 2, 4, 6, and 8 hours of heating-up time
* connection voltage of ~230 V, 3~400 V, and 3N~400 V

### European Water Closet

The WC pan shall be manufactured of vitreous china and shall be of the flush down type and in white colour. The pan shall have flushing rim to wash to entire internal surface of the bowl without splashing and shall be of the floor mounted type. Floor fixing screws shall be of non-ferrous material. The seat and cover shall be manufactured of white coloured plastic, unless otherwise ordered by the Engineer. The seats shall be flat on the underside and provided with four rubber or plastic buffers to rest on the WC pan rim. The cover and seat shall be fixed directly to the WC pan with copper hinges and compressible protective washers on both sides of the ceramic lugs.

The flushing cistern shall be of low level type, connected to the WC pan by a PVC flushing pipe. The cistern shall be manufactured of vitreous china and shall be of the valveless siphon type of 9 l capacity. The cistern shall be provided with a suitable ball valve, operating handle direct mounted, water supply connection and overflow pipe discharging indirectly to a suitable conspicuous outlet. The flush pipe shall be of 32 mm bore. The fill fittings shall be of the quiet type and the flush pipe shall ensure the discharge of the total contents of the cistern.

All WC pans shall be provided with a toilet roll holder.

### Squatting (Asian) Water Closet

The squatting WC shall consist of the pan, high level flush cistern, flush pipe, flush chain and handle and all other necessary accessories. The WC pan shall be manufactured of vitreous china and consist of a floor level bowl with a squatting plate which is provided with raised foot treads. The plate forms and impervious surround and shall be formed in one piece with the bowl. The bowl shall be provided with a back flush inlet and may be supplied with or without an integral. The flushing cistern shall be provided with a ball valve, siphon flush fittings and an overflow pipe discharging indirectly to a conspicuous outlet. The flush pipe shall be of PVC or painted galvanised steel with a diameter of 32 mm. The cistern shall have a capacity of 9 l. All units shall be in white colour.

### Bowl Urinals

The urinals shall be wall hung urinals provided with an extended lip and a spreader for flushing water to the whole internal surface of the bowl. The urinals shall be of vitreous china complete with outlet grids.

All urinals shall be provided with flushing. A single unit shall be provided with a manually operated flushing cistern. When the urinals are installed in ranges, they shall be provided with an automatic flushing cistern and dividing panels. The cistern shall discharge its contents automatically by siphonage, at intervals determined by the rate of water input to it. The capacity shall be 4.5 l of water per standing space while the water supply shall be provided with a regulating cock and stop valve.

### Wash Basins

The wash-basins shall be of vitreous china, wall hung and in white colour. The wash-basins shall be provided with a waste connection, piped water supply, overflow outlet, plug and chain and water taps.

The wash-basin shall be designed to eliminate splashing and spillage. All exposed metalwork shall be chrome plated. The wash-basin shall be supported by wall brackets of painted steel firmly fixed to the wall. Each basin shall form a waterproof edge with the wall. A mirror of approximately 40 x 60 cm shall be provided and fixed above each washbasin.

### Showers

Showers shall be fixed complete including shower bases made of enamelled steel, piped hot and cold water supply, wall mounted taps and floor drains. All shower rooms shall be provided with a built-in soap holder and a shower curtain rail. The floor in the shower rooms shall be provided with a sill.

### Sinks

The sink-units shall be manufactured of stainless steel and each sink shall be formed in one piece.

The sinks shall be provided with a single drainer, including plugs and chains, wastes and traps, piped water supply and taps. The sinks shall be provided with suitable built-in pipework, taps and fittings shall be chromium plated.

### Testing of Sanitary System

The sanitary system shall not be accepted until it has been tested as specified below. All tests shall be conducted in the presence of the Engineer. No part of the sanitary system shall be painted, covered or enclosed until it has been tested, inspected and accepted. All equipment, materials, instruments and labour necessary for testing and inspection shall be provided by the Contractor, to execute the work as directed.

### Pressure Tests of Drainage

The piping of the plumbing and drainage system shall be tested with water. After the plumbing fixtures have been set and their traps filled with water, the entire drainage system shall be submitted to a final test. The water test shall be applied to the drainage system in its entirety or in sections. If applied to the entire system, all openings in the piping shall be tightly closed, except the highest opening, and the system filled with water to the point of overflow. If the system is tested in sections, each opening shall be tightly plugged except the highest opening of the section under test. Each section shall be filled with water but no section shall be tested with less than 3 m head of water.

The Contractor has to install temporarily a pipe of 3 m height in order to apply 3 m head at the uppermost sections of the system. The water shall be kept in the system, or in the portion under the test, for at least 4 hours before inspection starts. The system shall then be tight at all points.

### Pressure Tests of Water Supply Pipes

Upon completion of the potable water distribution system, it shall be tested and proved tight under a water pressure of 1 MPa or 150% of the working pressure, whichever is higher. Care shall be taken that no appliance or fitting shall be pressurised higher than its rating. If such an appliance is included in the testing circuit, it shall be blinded prior to applying the pressure. A hand pump shall be used for this purpose. All lines shall be properly plugged or capped, making sure that all air has been vented from the system before pressure is applied. The pressure shall remain constant without pumping for a period of 8 hours.

If any leaks in joints or evidence of defective pipe or fitting is disclosed, the defective work shall be immediately corrected by replacing defective parts with new joints or materials. No makeshift repairs or application of patching compounds shall be permitted. After the correction is made, supplementary tests shall be run until a satisfactory working condition is obtained.

### Flow Test

A flow test shall be made of all the sanitary system components and in case any obstructions are encountered in the piping or equipment, the Contractor shall disassemble, clean, repair and reassemble such piping or equipment.

A watertight test for sleeves and the passage of pipes through floor and roof shall be made. The Contractor shall repair any leaks.

## Home Appliance and Furniture

### Air Conditioner

Air conditioner shall be split type and shall be reliable, almost maintenance-free, highly stabile

Configuration

* Air swing
* Removable, washable intake grill
* cooling speeds / 2 fan only speeds
* 4-way adjustable front louvers to deflect the airflow horizontally and vertically
* Ventilation control (open / close)
* Electrostatic filter to clean air by removing particles of dust, pollen, and smoke

Control

* Setting timer for switching off the AC-unit in one-hour increments, up to 12 hours from the present time
* Control panel to set the temperature, timer, operation mode (“Auto”; “Cooling”; “Dry”; “Fan”) and fan speeds, with LED display to give of all settings
* Remote controller for all functions
* Material and Finishing
* Steel frame with ABS cover.

Technical Data

* Operating temperature range: 16 – 32°C
* Energy Efficiency Ratio (EER): minimum 3 W heating power / W power consumption (measured according to ISO 5151)
* Air flow indoor unit: minimum 450 m3/h
* Noise level indoor unit: maximum 35 db(A)
* Noise level outdoor unit: maximum 50 db(A)
* Refrigerant: Environmentally friendly refrigerant -CFC free
* Power supply/ consumption: 230 V / 50 Hz / maximum 5,000 W

Approvals

CE, GS, VDE, TÜV or equivalent

### Refrigerator

Specifications

* fridge capacity (net): 150 l
* bottom 4 star freezer capacity: 40 l
* energy saving: class A
* temperature control: 2 thermostats
* defrost system: push-button, auto restart
* evaporators: 2 aluminium roll-bonds fully enclosed
* condensers: concealed
* compressors: 2 independently controlled air cooled units
* cooling agent: non-chlorofluorocarbon (CFC- and HFC-fee)

Material and Finish

* Frame: Steel
* Finish: Acrylic enamelled, white
* Door seal: EPDM
* Thermal insulation: rigid PU foam

Accessories

* Full height hinged self-closing door (magnetic)
* 2 Flush mounted digital thermometer (fridge and freezer)
* height adjustable chrome plated wire shelves
* 2 vegetable compartments
* 2 Indicator lights for ON/OFF

## Piping for House Installations

Pexal piping as composite multi-layer pipe consisting of polyethylene outer and inner with an aluminium core (called PE/AL/PE) can be applied. It shall be approved under the requirements of AS 5601 (AG 601). Only brass fittings are to be used, only the Pexal tools should be used to connect these fittings. Pipe should not be exposed to direct sunlight.

## Miscellaneous

### Fire Protection

Portable fire extinguishers shall be installed in all buildings at strategic positions (stair cases, corridors) in a manner that traffic will not be obstructed. As a further condition, extinguishers shall be located at easily visible and accessible locations regarding the event of a fire.

Preferably dry chemical extinguishers, multipurpose type, shall be supplied. As a rule powder units containing 12 kg shall be supplied, which combine all of the extinguishing effects, and are permitted for fires of class A to C in the presence of electrical voltage up to 1,000 V. For class D fires involving combustible metals dry compound extinguishers shall be introduced. The portable fire extinguishers shall be fitted with spring headed interchangeable safety valves.

Rooms and areas where voltages above 1,000 V are to be expected, housing relays, control and computer units shall be equipped with portable carbon dioxide extinguishers in addition. Also suitable masks to prevent any injury to personnel shall be supplied.

All extinguishers shall be designed for service over a period of 20 years taking the conditions at the site into account.

The extinguishers must be provided as early as possible, however, at latest on commencement of the commissioning preparations.

After completion of the installation, random tests of 5% of the portable extinguishers supplied shall be performed. The Contractor shall provide the necessary refills.

The following arrangement criteria shall be met:

* Maximum travel distance to an extinguisher: 22 m
* Maximum areas to be protected per extinguisher: 500 m²

### Lifebuoys

Lifebuoys, where applicable, shall be canvas covered cork complying with the requirements of prEN 14144.

Each lifebuoy shall be attached a 30 m length of buoyant lifeline knotted at every 3 m.

Holders for life buoys shall comply with prEN 14145 and shall be mounted on a galvanised mild steel support frame suitable for grouting into or bolting onto a horizontal concrete surface. The frames shall be such that the centre of the lifebuoys shall be approx. 1.5 m above the horizontal concrete surface. The locations for lifebuoys shall be advised by the Engineer.

### Hydrants

Hydrants shall be post or underground fire hydrants complying with EN 14339 or EN 14384 or equal.

Post Hydrant = Above Ground!

Setting:

* base central type which ends up to a flange in the appropriate nominal diameter to connect to the service water pipe
* body with antifrost protection and automatic evacuator
* head with one or two outlets ND 65, house connection type C
* valve type 'n' or 'hp' which opens with course opposited to the flow
* hand-wheel for operation

Material:

* Stopper, retaining ring, guide, bonnet tip, breaking ring, inlet piece, lower part of barrel, ductile cast iron
* Upper part of barrel, spindle nut, spindle guide: brass
* Bush, square socket, stem, key rod, spindle: stainless steel
* Retainer ring, cords for outlet, caps, bolts, double cut-off ball, drain: thermoplastic
* Protection, guide star, bonnet: duroplastic
* Rubber coating of stopper: elastomer

Corrosion protection:

* Internal: vitreous enamel
* External underground: vitreous-enamel primer with 2-coat synthetic resin
* External above ground: duplex coating consisting of spray zinc coating with covering coat on EP/PUR basis

### Boots Washing Unit

Made completely from stainless steel 1.4301, for mounting flash with surface, equipped with:

* trough for installation of brushes, water connection by solenoid valve, with connection to the wastewater system,
* nylon rotating sideways and bottom brushes
* frame to hold on with mounting for the
* hose connected brush with handle, operation by means of a grip-switch (simultaneously the water inlet is opened by a solenoid valve)

1. CBR = California Bearing Ratio: The load-supporting capacity of a soil as compared to that of standard crushed limestone, expressed as a ratio. A soil having a CBR of 16 supports 16% of the load that would be supported by standard crushed limestone, per unit area, with the same degree of distortion. [↑](#footnote-ref-1)
2. Eurocode 2: Design of concrete structures [↑](#footnote-ref-2)
3. Eurocode 2: Design of Concrete structures - Part 3: Liquid retaining and containment structures [↑](#footnote-ref-3)