

Technical Specification

T0001

Civil Engineering - Track and Off-track Gravity Drainage Systems



**Please read the Written Notices
attached to this standard**

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1 Purpose

- 1.1 The purpose of this Specification is to provide designers and tenderers / contractors with the minimum technical standards and physical requirements that Track and Off-track Drainage gravity systems shall be designed and constructed to meet.

2 Scope

- 2.1 This Specification applies to all Track and Off-track gravity drainage systems designed and constructed by or for London Underground Ltd (LUL).

3 Specification

3.1 Preamble

- 3.1.1 This specification is substantially based on the Department for Transport's Specification for Highway Works (SHW), Series 500 Drainage and Service Ducts (incorporating November 2009 amendments) and (but to a far lesser extent) on the UK Water Industry Research publication, the Civil Engineering Specification for the Water Industry (6th Edition) (CESWI). Significant editing has taken place to improve the relevance of source Clauses in the context of railway drainage installations generally and London Underground (LU) infrastructure specifically. Many Clauses within this specification retain references to other SHW series Clauses (eg. Earthworks Series 600 Clauses), in such cases the specific requirements of the referenced SHW Clause are deemed to apply.
- 3.1.2 This specification is as far as possible, a performance based standard. However, given that the LU environment is rather unique in certain respects, some prescription remains in the document.
- 3.1.3 This document is generic in form and not tied to either the Institution of Civil Engineers Conditions of Contract (Measurement Version)(7th Edition) or the Civil Engineering Standard Method of Measurement (3rd Edition) or the Manual of Contract Documents for Highway Works Volume 4 Bills of Quantities for Highway Works.
- 3.1.4 The document contains references to the 'Client', 'Engineer' and 'Contractor'. It should be noted that in the context of this specification those terms shall be taken to have logical meaning in the broad senses of the words and shall be viewed as independent of the specific Conditions of Contract. Thus the term 'Client' shall be taken to mean Employer, Authority, Purchaser, etc; similarly 'Contractor' shall mean 'Contractor' in the traditional contractual sense if appropriate, or shall mean the relevant entity within other forms of contract such as alliancing and joint ventures, etc; and the term 'Engineer' shall also be construed in a generic sense to mean Contract Administrator, Project Manager, etc. as appropriate to the contract.
- 3.1.5 There is no reference in the specification to satisfy legislation. This follows the general principle that the works are to be constructed to comply with all relevant statutes.
- 3.1.6 This specification provides broad guidance on acceptable materials and levels of workmanship. However, in common with both CESWI and SHW, the standard requirements of this specification must be augmented for each discrete package of work with a *contract specific appendix* (sometimes referred to as a '*Particular Specification*'). In conjunction with this specification, the contract specific appendix is referred to as *Appendix D1*; it shall contain contract specific information and requirements. Further guidance on the preparation of the contract specific Appendix D1 is given at the end of this specification in Section 7.1 - Attachment 1.



3.2 General

3.2.1 Terms and Abbreviations

- 3.2.1.1 Unless specifically defined otherwise in Clauses 6.2 and 6.3, the definitions of terms used in the Specification and associated documents are those in BS 6100, Glossary of Building and Civil Engineering Terms.

3.2.2 British, European and International Standards

- 3.2.2.1 British, European and international standards shall be deemed to be those current 28 days prior to the date for return of tenders, or those current at the date of receipt of this specification document, whichever may be applicable.

3.2.3 Health, Safety, Environment and Quality

- 3.2.3.1 The current version of LU Category 1 Standard 1-551 Procuring and Managing Suppliers and Contractors – HS & E Requirements, shall be complied with during all construction, installation, testing and commissioning work.
- 3.2.3.2 New works and maintenance work shall comply with BS EN 752 Clause 7 Health and Safety Principles.

3.2.4 Existing and As-built Survey Drawings

- 3.2.4.1 Where required by the contract, as-built drawings shall be provided in electronic format and comply with the current version of LU Category 1 Standard 1-037 Computer Aided Design Data and the particular requirements of Appendix D1.

3.2.5 Impact on Outside Party Assets

- 3.2.5.1 Where required by the contract, the impact on Outside Party assets shall be determined in accordance with the current version of LU Category 1 Standard 1-023 Infrastructure Protection.

3.2.6 Contractor Designs

- 3.2.6.1 All items to be designed by the Contractor shall be scheduled in Appendix D1 together with all applicable design standards and scopes of work.
- 3.2.6.2 The Contractor shall provide a fully signed-off Design Check Certificate for the category of check undertaken and appropriate for the asset designed in accordance with the current version of LU Category 1 Standard 1-538 Assurance.

3.3 Technical

3.3.1 General

- 3.3.1.1 Where the term 'drain' is used in this section of the specification, it shall be deemed to include the terms 'sewer' and 'piped culvert'.
- 3.3.1.2 Where the term 'drain' is used in this section of the specification, it refers to manufactured pipes with diameters of 900mm or less. Pipes with diameters greater than 900mm are classified as structures and are not subject to this specification.
- 3.3.1.3 Unless otherwise described in Appendix D1 only one type of pipe shall be used within any individual drain between consecutive chambers. The Contractor shall ensure that plastics pipes are not subject to deterioration due to sunlight during the period between manufacture and installation in the ground.
- 3.3.1.4 The Design Life of drainage assets shall be in accordance with Table 3.3.1.1 unless identified otherwise in Appendix D1. Evidence of compliance shall be in the form of Agrément Certificates or other verified testing and copies of such certificates and test data shall be supplied to the Engineer.



Drainage asset	Design life
Drainage assets (unless stated otherwise)	60 years
Catchpit covers	20 years
Brick drain	125 years
Non brick drain (other than hydrocarbon-based materials) i.e. clay, concrete pipe	100 years
Pipes made from hydrocarbon-based materials e.g. High Performance Polyethylene (HPPE); and CIPP lining systems.	40 years

Table 3.3.1.1 – Design Life of Drainage Assets

- 3.3.1.5 All materials supplied under the contract shall comply with the requirements of the current version of LU Category 1 Standard 1-050 Civil Engineering – Common Requirements.
- 3.3.1.6 LU maintains a Products Register (<http://www.lu-apr.co.uk>); only products appearing on that register may be incorporated into the works. Should a supplier or contractor wish to use a product not on the register then special approval (from the LU *Principle Engineer for Pumps and Drainage*) will need to be sought and granted before it can be incorporated in the works.

3.3.2 Pipes for Track and Off-track Gravity Drainage

- 3.3.2.1 Pipes for Track and Off-track gravity drainage shall be selected from the alternatives listed in Table 3.3.2.1 unless clause 3.3.2.2 applies and shall comply with the standards and particular requirements therein. The contractor shall show that the pipes he selects have hydraulic flow capacity equal to that assumed in the hydraulic design of the system as described in Appendix D1.

On completion of the whole of the works, the Contractor shall provide the Engineer with a schedule showing details of all pipe types used, including quality, joints and name of manufacturer.

- 3.3.2.2 If pipes manufactured from materials other than those shown in Table 3.3.2.1 are required to be used, they shall be specified in Appendix D1.

Material	Usage	Standard	Particular Requirements
Vitrified clay (VC).	Surface and ground water carrier drains.	BS 65 or BS EN 295	"Normal" or "surface water" pipes as defined in BS 65.
	Surface and ground water filter drains.	BS EN 295	Perforated with flexible mechanical joints.
Concrete (with Portland Cement or Sulphate-Resisting Portland Cement when required in Appendix D1. Super-sulphated cement shall not be used).	Surface and ground water carrier drains.	BS 5911-1 and BS EN 1916 (Ordinary reinforced or unreinforced)	
		BS 5911-5	
Iron	Surface and ground water carrier drains.	BS EN 598 (Ductile iron)	
Thermoplastics solid wall pipes and fittings.	Surface and ground water carrier drains.	BS EN 1401 (PVC-U) BS EN 1852-1 (PP)	
Unplasticised			



polyvinyl-chloride (PVC-U). Polypropylene (PP). Polyethylene (PE).		BS EN 12666-1 (PE)	High Performance Polyethylene (HPPE) grades PE80 and PE100 only.
		DIN 8074 & 8075 (PE)	High Performance Polyethylene (HPPE) grades PE80 and PE100 only.
	Surface and ground water filter drains.	BS EN 1401 (PVC-U) BS EN 1852-1 (PP)	
		BS EN 12666-1 (PE)	High Performance Polyethylene (HPPE) grades PE80 and PE100 only.
		DIN 8074 & 8075 (PE)	High Performance Polyethylene (HPPE) grades PE80 and PE100 only.

Table 3.3.2.1 Pipes for Track and Off-track Gravity Drainage

3.3.2.3 The following are **not** permitted:

- Use of rigid or semi-rigid pipes with rigid joints for any buried pipeline.
- The use of *twin-walled* or *structured wall* plastic pipes.
- The use of open jointed pipes.

3.3.2.4 All filter drainage shall employ perforated pipes with the following characteristics:

- Perforations should be not less than 1000mm² per metre length of pipe or 1% of the pipe external surface area per metre length of pipe – whichever is the greater; and should not reduce the pipe stiffness by more than 5%.
- Circular perforations should be between 10mm and 6mm in diameter.
- Rectangular slots should be between 7mm and 3mm in width (unless stipulated otherwise in Appendix D1).
- Perforations shall be distributed in a minimum of three rows, each row shall be no more than 90° from the adjacent row.
- Perforated pipes shall only contain perforations within the top half of the pipe unless stipulated otherwise in Appendix D1.

3.3.2.5 Use of hydrocarbon based pipes

3.3.2.5.1 The use of hydrocarbon based pipe materials in particular (and any other materials in general) which fail to meet the requirements of the current version of LU Category 1 Standard 1-085 Fire Safety Performance of Materials, in respect of flammability, smoke emission and toxic fume emission in Sub-surface Railway areas, shafts and tunnels (both bored tunnel and cut & cover tunnel forms), is not permitted unless a concession / fire waiver is obtained against the standard.

3.3.2.5.2 A concession / fire waiver for use of High Performance Polyethylene (HPPE) exists (LU ref. CR03003). This material is permitted for use as track drainage in sub-surface railway when buried under a minimum depth of 500 mm of track ballast and/or inert gravel, and when exposed pipe ends have been treated in one of the following two ways:

- The ends of the pipe to be cut off and trimmed back 30-50mm to the chamber wall and the annulus sealed off at the end with epoxy mortar. In accordance with standard detail drawing *Proposed Option 1* (Ref. NNNN0000-DWG-DRN-SA00-5390001).
- The ends of the pipe to be entirely encased by an aluminium fire protection pipe cap. The protection pipe cap is screwed into the chamber wall. In accordance



with standard detail drawing *Proposed Option 3* (Ref. NNNN0000-DWG-DRN-SA00-5390003).

3.3.2.5.3 A second concession for the use of HPPE pipe exists (LU ref. CR05565) that permits its use as track drainage in Sub-surface Railway, shafts and tunnels (both bored tunnel and cut & cover tunnel forms) when covered by a minimum depth of inert gravel of 130mm and enclosed in a fire barrier sock in accordance with Clause 3.3.4.8. Where the depth of cover is 500mm or greater, the fire barrier sock is *not* required and the requirements of concession CR03003 shall apply. Under this concession (LU ref. CR05565) exposed pipe ends must be cut back flush with the internal walls of chambers they are built into. No further special treatment of the pipe ends is required *if* the chambers involved are covered by solid covers or planks (made from suitable fire-resistant materials). However, if open covers or gratings are used, then the exposed pipe ends must be treated in accordance with concession CR03003 (i.e. as described above in Clause 3.3.2.5.2).

3.3.2.6 When pipes are required beneath and across the track, flexible joints shall be located within the Six Foot, Ten Foot and the Cess, such that pipeline articulation is possible and a degree of differential settlement can be accommodated.

3.3.3 Excavation for Pipes and Chambers

3.3.3.1 The Contractor shall employ only plant and working methods which are suited to the materials to be handled and traversed. He shall be responsible for maintaining the nature of the acceptable material so that when it is placed and compacted it remains acceptable in accordance with the contract. Acceptability shall be determined in accordance with Table 6/1 of the SHW and any contract specific requirements in Appendix D1.

3.3.3.2 The Contractor shall ensure that he does not adversely affect the stability of excavations or fills by his methods of stockpiling materials, use of plant or siting of temporary buildings or structures.

3.3.3.3 Excavations for foundations and trenches shall be adequately supported at all times, and, except where otherwise described in Appendix D1, shall not be battered. Where excavations are permitted to be battered they shall be benched as described in Appendix D1 and/or on the Contract drawings prior to backfilling and compaction. The additional work and materials shall be provided by the Contractor. Sheet piling and other excavation supports shall be removed as filling proceeds except where they are required by the Contract to be left in position, in which case the requirement shall be stated in Appendix D1.

3.3.3.4 Excavations requiring backfilling shall remain open only for the minimum period necessary. Where such excavations are within 2 metres of the nearest running rail, the maximum length of excavation which can be opened at any one time is 15 metres (except when clause 3.3.3.5 applies) but this may be reduced by the Engineer on site following his assessment of the ground conditions and adjacent engineering train loading.

3.3.3.5 In exceptional circumstances the maximum length of excavation may be increased beyond 15m subject to a formal load bearing capacity assessment of the ground and adjacent engineering train loading conditions by a suitably experienced and qualified Geotechnical Engineer.

3.3.3.6 The Contractor shall keep earthworks free of water including:

- a) arranging for the rapid removal of water
 - i. shed on to the earthworks;
 - ii. entering the earthworks from any source;
- b) lowering and maintaining by appropriate measures, the water level in excavations, sufficiently to enable the Permanent Works to be constructed.



- 3.3.3.7 In carrying out the requirements of sub-Clause 3.3.3.6 of this specification the Contractor shall:
- a) form and maintain cuttings, embankments and other areas of fill with appropriate falls and gradient and sealed surfaces;
 - b) provide where necessary temporary watercourses, drains, pumping and the like;
 - c) discharge accumulated water and groundwater into the permanent outfalls of the drainage system where practicable;
 - d) provide adequate means for trapping silt on temporary systems discharging into permanent drainage systems.
- 3.3.3.8 The Contractor shall carry out and maintain any groundwater lowering or other treatment required in Appendix D1.
- 3.3.3.9 Soft spots existing below the bottom of an excavation shall be removed and the resulting voids backfilled with either of the following:
- a) Type 1 unbound mixture for sub-base complying with SHW Clause 803, well compacted.
 - b) Pipe bedding material complying with SHW Clause 503, well compacted.
- 3.3.3.10 Any additional excavation below the bottom of an excavation that is required because the Contractor has allowed the bottom to become soft or otherwise unacceptable for the construction of the pipeline or chambers shall be made good as described in sub-Clause 3.3.3.9 of this Clause.
- 3.3.3.11 Any excavation greater than the net volume required for the Permanent Works below the level of the pipe surround shall be made good as described in sub-Clause 3.3.3.9 above.

3.3.4 Bedding, Laying and Surrounding of Pipes

- 3.3.4.1 Immediately following the excavation of the trench, the pipes shall be laid so that each one is in contact with the bed throughout the length of its barrel. The pipes shall be laid at the levels and gradients shown on the drawings and schedules. The deviation in level from that specified at any point shall not exceed 20mm and in addition the algebraic difference of the deviation in level at any two points on each pipe shall not exceed 30mm. In the case of socketed or sleeve jointed pipes the bed shall be cut away and removed at each socket or sleeve to give a clearance of at least 50mm, or 100mm for trenches in material designated as Hard Material, so that the socket or sleeve does not bear on the bed. Pipes shall be laid on setting blocks only where a concrete bed or cradle is used.
- 3.3.4.2 Pipes and fittings shall be examined for damage and the joint surfaces and components shall be cleaned immediately before laying. Measures shall be taken to prevent soil or other material from entering pipes, and to anchor each pipe to prevent movement before work is complete.
- 3.3.4.3 Track and Off-track surface and ground water filter drainage pipe and bedding combinations shall be a product of a perforated pipe type selected from Table 3.3.2.1 and a Bedding Class S (for rigid pipe materials) or S1 (for semi-rigid and flexible pipe materials) in accordance with BS EN 1295-1 Tables NA.7 & NA.8 respectively and the installation dimensions shown on the Type S detail on standard detail drawing SHW HCD F1. The granular material shall consist of natural and/or recycled coarse aggregate or recycled concrete aggregate complying with BS EN 12620. Where recycled coarse aggregate or recycled concrete aggregate is used in this Clause, it shall have been tested in accordance with SHW Clause 710 and shall not contain more than 1% other materials (Class X). Pipe bedding, haunching and surround material shall be in accordance with the following:

- a) For pipes on Classes S and S1 beds in accordance with BS EN 1295-1 Tables NA.7 & NA.8 respectively, the aggregate shall have:
 - i. geometrical requirements in accordance with Table 3.3.4.1;
 - ii. a resistance to fragmentation in Category LA₅₀ in accordance with BS EN 13242, Clause 5.2 and Table 9;
 - iii. a water-soluble sulphate content of less than 0.38% of sulphate (as SO₃) when tested in accordance with BS EN 1744-1, Clause 10;
 - iv. all other requirements in Category NR.
- b) Unless otherwise described in Appendix D1 the material used for the bedding, haunching and surrounding of filter drains shall comply with the appropriate bedding, haunching and surrounding materials specified in this Clause and with the requirements for backfilling specified in sub-Clause 3.3.6.4.

BS EN 13242, Coarse aggregate (Clause 4.3.2)		
Category for general grading requirements	G _C 80-20	
Category for tolerances at mid-size sieves	GT _{NR} (no requirements)	
Category for maximum values of fines content	Gravel – $f_{1.5}$ Crushed rock, recycled aggregate – f_4	
Nominal pipe diameter, mm	Aggregate size, mm	
	Graded	Single-sized
Exceeding 140 but not exceeding 215	No option	10/20 or 14/20
Exceeding 215	No option	10/20, 14/20 or 20/40

Table 3.3.4.1 – BS EN 13242, Coarse Aggregate for Pipe Bedding, Haunching and Surrounding Material to Track and Off-track Surface and Ground Water Filter Drainage

3.3.4.4 Track and Off-track surface and ground water carrier drainage pipe and bedding combinations shall be a product of an unperforated pipe type selected from Table 3.3.2.1 and a Bedding Class S, S2 or A (or Type Z if required). Bedding Classes S and A (which are for rigid pipe materials) shall be in accordance with BS EN 1295-1 Table NA.7; bedding class S2 (which is for semi-rigid and flexible pipe materials) shall be in accordance with BS EN 1295-1 Table NA.8. The installation dimensions for Bedding Classes S and S2 shall both be in accordance with the Type S detail shown on standard detail drawing SHW HCD F1. The installation dimensions for Bedding Class A shall be in accordance with the Type A detail shown on standard detail drawing SHW HCD F1. Bedding Type Z for rigid (or in special cases semi-rigid and flexible) pipe materials shall be in accordance with the installation dimensions for Bedding Type Z detail shown on standard detail drawing SHW HCD F1 and the requirements of this sub-Clause. Granular material shall consist of natural and/or recycled coarse aggregate or recycled concrete aggregate complying with BS EN 13242. Where recycled coarse aggregate or recycled concrete aggregate is used in this Clause, it shall have been tested in accordance with SHW Clause 710 and shall not contain more than 1% other materials (Class X). Pipe bedding, haunching and surround material shall be in accordance with the following:

- a) For pipes on Bedding Classes S or S2 in accordance with BS EN 1295-1 Tables NA.7 & NA.8 respectively, the aggregate shall have:
 - i. geometrical requirements in accordance with Table 3.3.4.2 or Table 3.3.4.3, note that for Track Drainage single-sized aggregate options from Table 3.3.4.2 may only be used where explicitly required in Appendix D1 as Bedding Class S1 in accordance with BS EN 1295-1 Table NA.7, otherwise all bedding aggregates in this sub-Clause used for Track Drainage shall be graded, fine or all-in aggregates;
 - ii. a resistance to fragmentation in Category LA₅₀ in accordance with BS EN 13242, Clause 5.2 and Table 9;



- iii. a water-soluble sulphate content of less than 0.38% of sulphate (as SO_3) when tested in accordance with BS EN 1744-1, Clause 10;
 - iv. all other requirements in Category NR .
- b) For pipes on Types A and Z beds as shown on standard detail drawing SHW HCD F1, the concrete shall be standardised prescribed concrete mixes ST4 and ST2 respectively, complying with BS EN 206-1 and BS 8500 and in compliance with i. to iii. below. Backfilling shall not be carried out until after the concrete has cured.
- i. Cement type CEM 1 (Portland Cement) to Table 1 of BS 8500-2, or where required in Appendix D1, SRPC (Sulphate Resisting Portland Cement).
 - ii. Aggregates shall comply with BS EN 12620 and have a minimum aggregate size of 20mm unless described otherwise in the Contract. The total acid-soluble sulphate content of the concrete mix, as SO_4 , shall not exceed 5% of the mass of cement in the mix. The acid-soluble sulphate (AS) shall be determined in accordance with Test No. 2 in TRL Report 447.
 - iii. The consistence of the concrete shall be defined by its consistence class (slump) and be within either consistence class S2 or S3 of BS EN 206-1 and BS 8500 as appropriate for the purpose.
- c) Except for filter drains, a further surround above the bed, haunch and surround (except Type Z beds) described above shall be provided to a height of 300mm above the top of the pipe consisting of Class 8 lower trench fill material as described in SHW Table 6/1 and in compliance with SHW Series 600 generally.

BS EN 13242, Coarse aggregate (Clause 4.3.2)		
Category for general grading requirements	$\text{G}_{\text{C80-20}}$	
Category for tolerances at mid-size sieves	GT_{NR} (no requirements)	
Category for maximum values of fines content	Gravel – $f_{1.5}$ Crushed rock, recycled aggregate – f_4	
Nominal pipe diameter, mm	Aggregate size, mm	
	Graded	Single-sized
Exceeding 140 but not exceeding 215	2/14 or 4/20	4/10 or 6/10 or 10/20
Exceeding 215	2/14 or 4/20 or 4/40	4/10 or 6/14 or 10/20 or 14/20 or 20/40

Table 3.3.4.2 – BS EN 13242, Coarse Aggregate for Pipe Bedding, Haunching and Surrounding Material to Track and Off-track Surface and Ground Water Carrier Drainage

BS EN 13242, Fine and all-in aggregate (Clause 4.3.3)		
	Fine	All-in
Category for general grading requirements	G_{C80}	G_{A80}
Category for tolerances on manufacturer's declared typical grading	GT_{FNR} (no requirement)	GT_{ANR} (no requirement)
Category for maximum values of fines content	Gravel – f_3 Crushed rock, recycled aggregate – f_{11}	
Nominal pipe diameter, mm	Aggregate size, mm	
	Fine	All-in
Exceeding 140 but not exceeding 215	0/1 or 0/2 or 0/4 or 0/6	0/10 or 0/20
Exceeding 215		0/10 or 0/20 or 0/40



Table 3.3.4.3 – BS EN 13242, Fine and All-in Aggregate for Pipe Bedding, Haunching and Surrounding Material to Track and Off-track Surface and Ground Water Carrier Drainage

- 3.3.4.5 Material for bedding, haunching and surrounding pipes shall not be deposited within 500mm of concrete, cement bound materials or other cementitious materials forming part of the permanent works.
- 3.3.4.6 Except where the pipeline is to be tested in compliance with Clause 3.3.10 before backfilling, the completion of the bedding, haunching and surrounding of the pipes is to be carried out immediately after jointing. The bed, haunch and surround shall be brought up equally on both sides of the pipe ensuring that it is in contact with the underside of the pipe barrel and be carefully compacted in layers not exceeding 150mm thickness ensuring full compaction next to the trench walls. Pipes shall be maintained to line and level during the bedding, haunching and surrounding operations. Where pipelines are to be tested before being covered, the bedding, haunching and surrounding material shall only be brought up sufficiently to support the pipeline and the joints shall be left exposed until the test is completed satisfactorily.

3.3.4.7 Geotextile Lining

- 3.3.4.7.1 The trench excavations for Track and Off-track surface and ground water filter drainage shall be constructed in accordance with the geometry indicated on LU standard detail drawing ST 71670 (refer to LU Manual of Good Practice G-052), and lined with geotextile in accordance with the same detail (but using a geotextile fabric compliant with sub-Clause 3.3.4.7.4 or 3.3.4.7.5). The detail ST 71670 shows the geotextile is not to be closed and lapped at the top of the trench; this is to permit the products of ballast attrition to enter the drainage system, whilst simultaneously preventing the migration of fines from the subgrade. Pipe bed, haunch, surround and trench backfill material shall be in accordance with the provisions of this Clause and not those shown on the detail ST 71670.
- 3.3.4.7.2 Closing and lapping the geotextile at the tops of Track and Off-track surface and ground water filter drainage trenches is only required when described in Appendix D1.
- 3.3.4.7.3 Where geotextile laps occur longitudinally within a filter drainage trench, the geotextile lap length shall be a minimum 300mm and the upstream sheet shall be lapped under the downstream sheet to minimise the migration of subgrade fines.
- 3.3.4.7.4 Geotextile used for the purposes defined in this sub-Clause shall meet the following requirements:
- a) either thermally bonded non-woven or needle-punched non-woven;
 - b) mean apparent opening size (AOS O_{90}) (in accordance with EN ISO 12956) of 100 μ m;
 - c) minimum permeability (H_{50})(in accordance with EN ISO 11058) of 90 litres/m²/sec;
 - d) minimum tensile strength (sometimes known as *breaking load*) (in accordance with EN ISO 10319) of 8kN/m;
 - e) minimum CBR puncture resistance (in accordance with EN ISO 12236) - mean peak strength of 1500N.
- 3.3.4.7.5 Where tree root penetration is considered to be a potential problem then geotextile used for the purposes defined in this sub-Clause shall meet the following requirements:
- a) thermally bonded non-woven;
 - b) mean apparent opening size (AOS O_{90}) (in accordance with EN ISO 12956) of 100 μ m;



- c) minimum permeability (H_{50}) (in accordance with EN ISO 11058) of 50 litres/m²/sec;
- d) minimum tensile strength (breaking load) (in accordance with EN ISO 10319) of 18kN/m;
- e) minimum CBR puncture resistance (in accordance with EN ISO 12236) - mean peak strength of 3250N

NOTE: The basis for the above specification (sub-Clause 3.3.4.7.5) is the proprietary product *Terram Root Guard*, which is Terram's thermally bonded non-woven fabric '*Terram 3000*' but with enhanced UV protection and pigment added. For use as a filter drain trench liner in the LU environment, the geotextile does not require UV protection or pigmentation, thus the above physical properties reflect those of *Terram 3000*. Terram Ltd have undertaken controlled testing to support their declared use of *Terram Root Guard* as suitable for preventing tree root penetration. Hence it provides the best available basis for the LU specification.

3.3.4.7.6 Locations where geotextile compliant with sub-Clause 3.3.4.7.5 is to be used shall be scheduled in Appendix D1. Should the Contractor identify additional locations where tree root penetration is considered to be a problem, he shall notify the Engineer immediately so that a change to the specified geotextile at those locations can be made.

3.3.4.7.7 In all cases, the required design life for geotextile and the above physical characteristics shall be confirmed by Agrément Certificates or other verified testing and copies of such certificates and test data shall be supplied to the Engineer.

3.3.4.8 Fire barrier socks shall meet the following requirements:

- a) fabricated from suitable woven glass fibre fabric;
- b) having a minimum '*weight*' of 400g/m²;
- c) having a minimum permeability (H_{50}) (in accordance with EN ISO 11058) of 5 litres/m²/sec;
- d) having external seams to facilitate sleeving over pipes;
- e) having double stitched seams for durability;
- f) utilising stainless steel thread;
- g) all edges adequately hemmed to prevent fraying;
- h) fabricated with a split seam at one end having a minimum length of 100mm to permit lapping over adjacent sleeves;
- i) fabricated with an internal diameter 10mm to 20mm larger than the external diameter of the pipe to be sleeved.

3.3.5 Jointing of Pipes

3.3.5.1 Rigid joints shall mean joints made solid by caulking the sockets, bolting together flanges integral with the pipes, screwing together of threaded pipes, or fusion (or solvent) welding of flexible pipe materials. Flexible joints shall mean joints made with deformable rings or gaskets held between pipe spigots and sockets, sleeves or collars.

3.3.5.2 Threaded joints are permitted for use where pipelines may be subject to high tensile forces; for example, during vertical installation as deep bored soakaways or when being winched through a host pipeline subject to pipe-bursting techniques. They may be employed with or without a deformable ring (according to the particular circumstances of use). In such cases, the joint shall offer a minimum tensile strength that is at least twice the maximum tensile stress that the joint will be subjected to during installation and in normal operation.

3.3.5.3 Manufacturers test data shall be provided to the Engineer to prove the tensile strength of the selected threaded joint. Threaded joints may permit a small amount of angular



rotation but are typically not classified as flexible joints; for the purposes of this specification they shall be regarded as rigid joints.

3.3.5.4 Watertight joints shall comply with the appropriate British or European Standards, the manufacturer's instructions and the following:

- a) Joints in PVC-U pipes shall not be made with plastic solvent.
- b) Flexible mechanical joints may be used with surface water pipes complying with BS 65.

3.3.5.5 Where a concrete bed, cradle or surround is used with rigid (or in special cases semi-rigid or flexible) pipes having flexible joints, joint filler board complying with SHW Clause 1015 shall be placed in contact with the end of the socket at the pipe joint and shall extend through the full thickness of the concrete in contact with the pipe. Such joints in the concrete bed, cradle or surround shall be at intervals not exceeding 5 metres except where the spacing of the joints in the pipe exceeds 5 metres when they shall be at each pipe joint.

3.3.5.6 Joints in pipes for filter drains shall comply with an applicable British or European Standard and with the following:

- a) The ends of perforated concrete pipes with rebated joints and perforated clayware pipes with rebated or sleeve joints shall be pushed tightly together.
- b) Perforated or slotted thermoplastic pipes with spigots and sockets or sleeves may be dry-jointed or jointed as unperforated pipes of the same material.

3.3.5.7 If an applicable British or European Standard does not exist, then the joint type shall only be used if it appears on the LU Products Register.

3.3.5.8 Pipe joints should be the proprietary type for the particular pipe used.

3.3.6 Backfilling of Trenches and Filter Drains

3.3.6.1 Backfilling shall be undertaken immediately after the required operations preceding it have been completed.

3.3.6.2 For the purposes of backfilling of track drainage, the top of the trench or filter drain shall be deemed to be track formation level, i.e. the level of the underside of the track support ballast.

3.3.6.3 Except where otherwise described in Appendix D1, trenches other than filter drain trenches shall be backfilled above the pipe surround material described in Clause 3.3.4, with a Class 1, 2 or 3 general fill material complying with SHW Series 600.

3.3.6.4 Backfilling of filter drains

3.3.6.4.1 Filter drains shall be backfilled as described in Appendix D1 with Type A, Type B, Type C or Type D filter material which shall consist of natural or recycled coarse aggregate or recycled concrete aggregate complying with BS EN 13242 and the following:

- a) for Types A and C, grading requirements for unbound mixtures in accordance with Table 3.3.6.1 and BS EN 13285;
- b) for Types B and D, geometrical requirements in accordance with Table 3.3.6.1 and BS EN 13242;
- c) a resistance to fragmentation in Category LA₅₀ in accordance with BS EN 13242, Clause 5.2 and Table 9;
- d) a water-soluble sulphate content of less than 0.38% of sulphate (as SO₃) when tested in accordance with BS EN 1744-1, Clause 10;
- e) all other requirements in Category NR;
- f) be non-plastic when tested in accordance with BS 1377:Part 2.