DIN EN 13941-1:2022-06 (E)

District heating pipes - Design and installation of thermal insulated bonded single and twin pipe systems for directly buried hot water networks - Part 1: Design (includes Amendment A1: 2021)

Contents

Page

European foreword ... 8

Introduction ... 10

1 Scope ... 11

2 Normative references ... 11

3 Terms and definitions, units and symbols ... 12
3.1 Terms and definitions ... 12
3.1.1 Symbols ... 13
3.1.2 Abbreviations ... 19

4 General requirements ... 19
4.1 Functional requirements ... 19
4.2 Service life ... 19
4.3 Preliminary investigations ... 20
4.4 Determination of project class ... 21
4.4.1 Risk assessment ... 21
4.4.2 Project classes ... 21
4.5 Design documentation ... 23
4.5.1 General ... 23
4.5.2 Operational data ... 24
4.5.3 Data related to the pipe system ... 24
4.6 Route selection and positioning of the pipes ... 26
4.6.1 Minimum distances between parallel pipes ... 26
4.6.2 Parallel excavations and works of third parties ... 27
4.6.3 Minimum distance between district heating pipes and underground structures ... 27
4.7 Venting and draining ... 27
4.8 Valves ... 27
4.9 Procurement of materials ... 28
4.9.1 Manufacturer of pipeline components ... 28
4.10 Quality control ... 28
4.10.1 General ... 28
4.10.2 Design phase ... 28
4.10.3 Installation phase ... 28

5 Requirements for components and materials ... 29
5.1 Basic requirements ... 29
5.2 Steel service pipe components ... 29
5.2.1 General ... 29
5.2.2 Specification ... 30
5.2.3 Characteristic values for steel ... 30
5.2.4 Specific requirements for bends and T-pieces ... 31
5.2.5 Specific requirements for small angular deviations ... 32
5.2.6 Specific requirements for reducers ... 33
5.3 Polyurethane foam thermal insulation ... 33
5.4 Casing ... 33
5.5 Materials for casing and thermal insulation of field joints ... 33
5.6 Expansion cushions ... 33
5.6.1 General ... 33
5.6.2 Materials ... 34

5.6.3 Stiffness properties 34
5.6.4 Selecting required thickness of expansion cushions 35
5.6.5 Marking 35
5.7 Valves and accessories 35
5.7.1 General requirements 35
5.7.2 Marking and documentation 36

6 Design and calculation 36
6.1 General procedure 36
6.2 Pipeline components, areas, conditions and interfaces to be included in the analyses 37
6.2.1 Components 37
6.2.2 Areas requiring specific analyses 38
6.2.3 Special conditions 38
6.2.4 Interfaces 38
6.3 Simplified analysis procedure 39
6.4 Actions 39
6.4.1 General 39
6.4.2 Classification of actions and load combinations 39
6.4.3 Temperature variations 41
6.4.4 Top load from soil 42
6.4.5 Traffic loads 42
6.5 Global analysis and pipe-soil interaction 44
6.5.1 General 44
6.5.2 Modelling pipe-soil interaction 44
6.5.3 Pipe to soil friction (axial) 46
6.5.4 Horizontal soil reaction (lateral) 48
6.5.5 Combined lateral stiffness of steel service pipe, PUR, expansion cushions and soil . 53
6.5.6 Soil properties 56
6.5.7 Thermal expansion of buried pipe sections: 56
6.5.8 Pipe systems with single use compensators (SUC's) 58
6.5.9 Specific requirements for vertical and horizontal stability 60
6.5.10 Parallel excavations 63
6.5.11 Requirements for soft soils and settlement areas 64
6.5.12 Specific design requirements for above-ground pipelines with factory made pipe and fitting assemblies 64
6.5.13 Insertion into protection pipe 64
6.6 Determination of stresses and strains 65
6.6.1 General 65
6.6.2 Cross section analyses, steel 65
6.6.3 Assessment on the basis of a resultant (equivalent) stress 66
6.6.4 Stresses and ovalization from top load 67
6.6.5 Deflection 69
6.6.6 Bends 70
6.6.7 T-pieces 71
6.6.8 Single Use Compensators (SUC's) 73
6.6.9 PUR and casing 76
6.7 Fatigue analyses 76
6.7.1 General 76
6.7.2 Action cycles 76
6.8 Further actions 79

7 Limit states 79
7.1 General 79
7.2 Limit states for service pipes of steel 80

7.2.1 General **80**
7.2.2 Limit state A: Failure caused by plastic deformation **80**
7.2.3 Limit state B: Failure caused by fatigue **83**
7.2.4 Limit state C: Failure caused by instability of the system or part of it **86**
7.2.5 Limit state D: Serviceability limit state **88**
7.2.6 Survey of limit states for steel **88**
7.3 Limit states for PUR and PE **91**
7.3.1 Compressive stress **91**
7.3.2 Limit state for [A1] axial <A1] shear stress **91**
7.3.3 Limit state for PE **91**
7.4 Limit states for valves **91**
Annex A (normative) **Design of piping components under internal pressure** **93**
A.1 General **93**
A.2 Straight pipe and bends **93**
A.2.1 Straight pipes **93**
A.2.2 Bends **93**
A.3 T-pieces and branch connections **94**
A.3.1 General aspects and limitations **94**
A.3.2 Reinforcement **94**
A.3.2.1 General **94**
A.3.2.2 Dissimilar material of shell and reinforcement **94**
A.3.2.3 Thickness ratio **95**
A.3.2.4 Calculation method for reinforcement area **95**
A.3.2.5 Reinforcement by increased wall thickness **95**
A.3.2.6 Reinforcement by compensating plates **96**
A.4 Reducers and extensions **97**
A.5 Dished ends **97**
A.5.1 General **97**
A.5.2 Ellipsoidal Dished Head Minimum required wall thickness for internal pressure **98**
A.5.3 Straight cylindrical shells **98**
Annex B (informative) **Soil properties and geotechnical parameters for pipe/soil interaction analyses** **99**
B.1 General requirements **99**
B.2 Geotechnical parameters for global analysis (pipe-soil interaction) **99**
B.3 Geotechnical Study **100**
B.3.1 Field study **100**
B.3.2 Typical values, referred to mean value **100**
B.3.3 Investigation of interface friction **100**
B.4 Characteristic values for soil properties **100**
B.4.1 Typical values, referred to mean value **100**
B.4.2 Spatial variation of soil properties **101**

B.5 Model uncertainty when determining geotechnical parameters **102**
Annex C (informative) **Flexibility and stress concentration of pipe components** **104**
C.1 General **104**
C.2 Flexibility factors for pipe components **104**
C.2.1 Bends **104**
C.2.2 T-pieces **104**
C.2.3 Other components **105**
C.3 Stress concentration in pipe elements **105**
C.3.1 Butt welds **105**
C.3.2 Bends **105**
C.3.2.1 Stress concentration factors for bends: Simplified method **105**
C.3.2.2 Stress concentration factors for bends: exact calculation **106**
C.3.3 T-pieces **108**
C.3.3.1 General **108**
C.3.4 Small angular deviations **109**
C.3.5 Reducers **110**
Annex D (informative) **Calculation of heat losses** **112**
D.1 General **112**
D.2 Heat losses of thermal insulated pipes **112**
D.2.1 Pair of single pipes — calculation of specific heat loss **112**
D.2.2 symmetrical and (a) antisymmetrical heat loss factors according to zero-order multipole formulae: **113**
D.2.3 Using Zero-order approximation for (s) symmetrical and (a) antisymmetrical problem the heat resistance can be calculated: **114**
D.2.4 specific heat loss of pipes **114**
D.2.5 Twin Pipes — calculation of specific heat loss **115**
D.2.6 temperatures of pipes **115**
D.2.7 (s) symmetrical and (a) antisymmetrical heat loss factors according to first-order multipole formula: **116**
D.2.8 specific heat loss of pipes **117**
Annex E (informative) **Specific requirements for twin pipe systems** **118**
E.1 General **118**
E.2 Component and materials **118**
E.2.1 Twin Pipe assembly **118**
E.2.2 Fixing bars **119**
E.3 Max. allowable stresses for specific twin pipe system elements: **120**
E.3.1 Project classes **120**
E.3.2 Soil friction, twin pipe friction length and pipe expansion **120**

E.3.3 Axial stress in the flow and return steel service pipes **122**
E.3.4 Dimensions of the fixing bars **124**
E.3.4.1 General **124**
E.3.4.2 loads on the fixing bars type A **125**
E.3.4.3 loads on the fixing bar type B **126**
E.3.5 Stress proof of the fixing bar **128**
E.3.6 Proof of the welds **129**
E.3.7 Vertical and horizontal stability of the twin pipe assembly in the soil **132**
E.3.8 Stress concentration factors for bends, T-pieces **132**
E.3.9 Fatigue **132**
E.4 Installation requirements **132**
E.4.1 Installation methods: **132**
E.4.2 Straight pipe section terminations: **132**
E.4.3 Use of insulated twin pipe valves: **132**
E.4.4 Use of transition assembly (twin pipe — single pipe): **132**
E.4.5 requirements for welding and testing of steel service pipe joints: **132**
Annex F (normative) **Compressive testing of expansion cushions** **133**
Annex G (informative) **Principles for determination of bending moments and axial forces for testing of district heating valves** **135**
G.1 Introduction **135**
G.2 General considerations for determination of test values for bending moments **135**
G.3 Determination of bending moments from soil settlements **136**
G.4 Calculation results and evaluation **136**
G.5 Resistance to axial forces **139**
Annex H (informative) **Scope of EN 13941 in relation to Pressure Equipment Directive (PED), 2014/68/EU, May 15th, 2014** **140**
H.1 General **140**
H.2 Guidelines **141**
Annex I (informative) **Quality control program and documentation** **144**
Annex J (informative) **Casing: Formulas for Miner Rule** **147**
Annex K (informative) **Strength calculation of horizontal directional drillings** **149**
K.1 Introduction **149**
K.2 Determination of pulling forces **150**
K.2.1 Pulling force, resulting from the roller system **150**
K.2.2 Pulling force, resulting from a straight section of borehole **150**
K.2.3 Pulling force, resulting from curved sections of the borehole **152**
K.2.3.1 General friction force **152**
K.2.3.2 Friction resulting from elastic soil reaction in curved borehole sections **152**

K.2.3.3 Friction due to the axial pulling force in curved borehole sections 153
K.2.3.4 Total force in a curved section 154
K.2.4 Total pulling force 154
K.3 Determination of the longitudinal bending moment 155
K.4 Determination of the circumferential bending moment from top load 155
K.5 Determination of stress 155
K.6 Assessment of possible collapse of the pipeline due to external drilling fluid pressure or external ground water pressure (risk of buckling) 155
K.7 Assessment of maximum soil pressure on PUR and casing 155
K.8 Determination of maximum allowable pressure in the bore hole 156
K.9 Vertical soil load after completion of horizontal directional drilling (HDD) 156
K.9.1 Introduction 156
K.9.2 Arching 156
K.9.3 Calculation method for vertical soil load (homogeneous soil mass) 156
K.9.4 Calculation method for horizontal support pressure (with reduced vertical load) 157
Bibliography 159