DIN EN 13480-3:2024-12 (E)

Metallic industrial piping - Part 3: Design and calculation

Contents

Page

European foreword ... 10

1 Scope ... 12

2 Normative references ... 12

3 Terms, definitions, symbols and units ... 13
3.1 Terms and definitions ... 13
3.2 Symbols and units ... 13

4 Basic design criteria ... 15
4.1 General ... 15
4.2 Loadings ... 15
4.2.1 General ... 15
4.2.2 Combination of loads ... 16
4.2.3 Loads for dimensioning ... 16
4.2.4 Other loads to be taken into account ... 18
4.2.5 Design conditions ... 19
4.3 Thickness ... 21
4.4 Tolerances ... 24
4.5 Joint coefficient ... 24
4.6 Dimensioning of piping components subject to pressure ... 25

5 Design stresses ... 25
5.1 General ... 25
5.2 Time-independent nominal design stress ... 26
5.2.1 Steels other than austenitic steels ... 26
5.2.2 Austenitic steels ... 26
5.2.3 Nickel and / or chromium alloy steels ... 27
5.2.4 Steels castings ... 27
5.2.5 Additional requirements for steels with no specific control ... 27
5.3 Time-dependent nominal design stress ... 28
5.3.1 General ... 28
5.3.2 Steels ... 28
5.3.3 Nickel and/or chromium alloy steels ... 29

6 Design of piping components under internal pressure ... 29
6.1 Straight pipes ... 29
6.2 Pipe bends and elbows ... 29
6.2.1 General ... 29
6.2.2 Symbols ... 30
6.2.3 Required wall thicknesses ... 30
6.3 Mitre bends ... 31
6.3.1 General ... 31
6.3.2 Symbols ... 31
6.3.3 Effective radius of mitre bend ... 32
6.3.4 Multiple mitre bends ... 32
6.3.5 Single mitre bends ... 33
6.3.6 Adjacent straight pipe sections of mitre bends ... 33
6.4 Reducers ... 33
6.4.1 Conditions of applicability ... 33

6.4.2 Specific definitions 34
6.4.3 Specific symbols and abbreviations 34
6.4.4 Conical shells 36
6.4.5 Junctions - general 36
6.4.6 Junction between the large end of a cone and a cylinder without a knuckle 37
6.4.7 Junction between the large end of a cone and a cylinder with a knuckle 39
6.4.8 Junction between the small end of a cone and a cylinder 41
6.4.9 Offset reducers 43
6.4.10 Special forged reducers 43
6.5 Flexible piping components 44
6.5.1 General 44
6.5.2 Expansion joints 44
6.5.3 Corrugated metal hose assemblies 46
6.6 Bolted flange connections 47
6.6.1 General 47
6.6.2 Symbols 47
6.6.3 Standard flange 47
6.6.4 Non-standard flange 48
7 Design of ends under internal pressure 48
7.1 Dished ends 48
7.1.1 Symbols 48
7.1.2 Hemispherical ends 49
7.1.3 Torispherical ends 50
7.1.4 Ellipsoidal ends 51
7.1.5 Calculation of β 52
7.2 Circular flat ends 56
7.2.1 General 56
7.2.2 Symbols 56
7.2.3 Unstayed flat circular ends welded to cylindrical shells/pipes 58
7.2.4 Unstayed flat circular bolted ends 65
7.2.5 Reinforcements of openings in unstayed flat ends 71
8 Openings and branch connections 74
8.1 General 74
8.2 Symbols 74
8.3 Limitations 75
8.3.1 Thickness ratio 75
8.3.2 Openings in the vicinity of discontinuities 77
8.3.3 Types of reinforcement 79
8.3.4 Calculation method 79
8.3.5 Elliptical openings and oblique branch connections 80
8.3.6 Reinforcing pads 81
8.3.7 Dissimilar material of shell and reinforcements 81
8.3.8 Extruded outlets 82
8.3.9 Forged tee 82
8.3.10 Branches in bends or elbows 83
8.3.11 Screwed-in branches 83
8.4 Isolated openings 84
8.4.1 General 84
8.4.2 Unreinforced openings 87
8.4.3 Reinforced openings with $d_i/D_i < 0,8$ 87
8.4.4 Reinforced single openings with $0,8 < d_i/D_i \leq 1,0$ 93
8.5 Adjacent openings 93

8.5.1 Unreinforced openings ... 93
8.5.2 Reinforced openings with $d_i/D_i \leq 0,8$ ... 93
8.6 Design of special piping components ... 94
8.6.1 Cylindrical Y-pieces ... 94
8.6.2 Spherical Y-pieces ... 95
8.6.3 Triform reinforced branches ... 96

9 Design of piping components under external pressure ... 97
9.1 General ... 97
9.1.1 External calculation pressure ... 97
9.1.2 Exception from verification against external pressure ... 98
9.1.3 General acceptance criteria ... 98
9.2 Symbols and elastic stress limits ... 99
9.2.1 Symbols ... 99
9.2.2 Stress limits ... 101
9.3 Cylindrical pipes, elbows and mitre bends ... 102
9.3.1 Determination of lengths ... 102
9.3.2 Interstiffener collapse ... 104
9.3.3 Overall collapse of stiffened pipes ... 105
9.3.4 Stiffener stability ... 106
9.3.5 Heating/cooling channels ... 109
9.4 Reducers (conical shells) ... 110
9.5 Dished ends ... 112
9.5.1 Hemispherical ends ... 112
9.5.2 Torispherical ends ... 113
9.5.3 Ellipsoidal ends ... 113

10 Design for cyclic loading ... 113
10.1 General ... 113
10.2 Exemption from detailed fatigue analysis ... 113
10.3 Fatigue design for cyclic pressure ... 114
10.3.1 Equivalent full load cycles ... 114
10.3.2 Simplified fatigue analysis ... 114
10.4 Fatigue design for thermal gradients ... 129
10.4.1 General ... 129
10.4.2 Design guidance ... 129
10.5 Fatigue design for combined loads ... 129

11 Integral attachments ... 130
11.1 General ... 130
11.2 Allowable stresses ... 130
11.3 Symbols ... 131
11.4 Hollow circular attachments ... 133
11.4.1 Limitations ... 133
11.4.2 Preliminary calculations ... 133
11.4.3 Analysis of attachments welded to pipe with a full penetration weld ... 135
11.4.4 Analysis of attachments welded to pipe with fillet or partial penetration weld ... 136
11.5 Rectangular attachments ... 136
11.5.1 Limitations ... 136
11.5.2 Preliminary calculations ... 136
11.5.3 Analysis of attachments welded to pipe with a full penetration weld ... 138
11.5.4 Analysis of attachments welded to pipe with fillet or partial penetration weld ... 139
11.6 Stress analysis of the run pipe ... 139
11.7 Shear stress analysis in attachment ... 141
11.7.1 Hollow circular attachments ... 141

11.7.2 Rectangular attachments 141
11.8 Alternative calculation methods 141

12 Flexibility analysis and acceptance criteria 142
12.1 Basic conditions 142
12.1.1 General 142
12.1.2 Loading conditions 142
12.1.3 Allowable stresses 142
12.2 Piping flexibility 144
12.2.1 General 144
12.2.2 Basic conditions 144
12.2.3 Displacement strains 144
12.2.4 Displacement stresses 145
12.2.5 Stress range 146
12.2.6 Cold pull 146
12.2.7 Properties for flexibility analysis 146
12.2.8 Supporting conditions 147
12.2.9 Expansion joints 148
12.2.10 Flexibility analysis 149
12.3 Flexibility analysis 151
12.3.1 General 151
12.3.2 Stress due to sustained loads 152
12.3.3 Stress due to sustained and occasional or exceptional loads 153
12.3.4 Stress range due to thermal expansion and alternating loads 155
12.3.5 Additional conditions for the creep range 157
12.3.6 Stresses due to a single non-repeated support movement 157
12.3.7 Determination of resultant moments 158
12.3.8 Reactions 160
12.4 Fatigue analysis 160
12.5 Vibration 160

13 Pipe Supports 161
13.1 General requirements 161
13.1.1 General 161
13.1.2 Classification of supports 162
13.1.3 Additional definitions 162
13.1.4 Boundaries 164
13.1.5 Pipe supports welded to the pipe 166
13.2 Selection of pipe supports 167
13.2.1 General 167
13.2.2 Detail design of pipe supports 168
13.2.3 Support location 169
13.3 Constant hangers/base mounted (pedestal) constant supports 169
13.3.1 General 169
13.3.2 Load deviation from calibrated load 169
13.3.3 Site adjustment of the calibrated load 169
13.3.4 Travel reserve (Overtravel) 169
13.3.5 Blocking 169
13.3.6 Identification Marking/Name plate 169
13.4 Variable load spring hangers and base mounted (pedestal) variable load spring supports 170
13.4.1 General 170
13.4.2 Tolerance on spring rate 171
13.4.3 Travel reserve (Overtravel) 171

13.4.4 Blocking **171**
13.4.5 Name plate **171**
13.5 Rigid struts **171**
13.6 Shock arrestors, shock absorber (snubber) **172**
13.7 Sliding supports **172**
13.8 Anchors **173**
13.9 Documentation of supports **173**
13.10 Marking of supports **173**
13.11 Design and manufacture of pipe supports **173**
13.11.1 Material requirements **173**
13.11.2 Design temperatures for support components **173**
13.11.3 Design details **175**
13.11.4 Determination of component sizes **175**
13.11.5 Welded connections **177**
13.11.6 Bolted connections **179**
13.11.7 Additional requirements on springs **182**
13.11.8 Design details for rigid struts **182**
13.11.9 Design details for shock arrestors, shock absorbers (snubbers) **182**
13.11.10 Clamps for shock arrestors, rigid struts **183**
13.11.11 Alternative rules for design and manufacture of pipe supports **184**

Annex A (informative) **Dynamic effect** **185**
A.1 General **185**
A.1.1 Introduction **185**
A.1.2 Vibration design guidelines **185**
A.2 Analysis by calculation **191**
A.2.1 General **191**
A.2.2 Seismic events **192**
A.2.3 Rapid valve closure **197**
A.2.4 Flow induced vibration **200**
A.2.5 Safety valve discharge **203**
A.2.6 Allowable stresses **205**
A.2.7 Structural vibration properties **205**
A.3 Alternative means of design verification **207**
A.3.1 Comparative studies **207**
A.3.2 Full scale testing **208**
A.3.3 Reduced scale testing **208**
A.4 Validation (measuring) **208**

Annex B (normative) **More accurate calculation of bends and elbows** **209**
B.1 General **209**
B.2 Symbols and units **209**
B.3 Required wall thickness **210**
B.4 Calculation **211**
B.4.1 Calculation of wall thickness **211**
B.4.2 Stress calculation **213**

Annex C (informative) **Expansion joints** **217**
C.1 Incorporation of expansion joints into piping systems **217**
C.1.1 General **217**
C.1.2 Types of expansion joints **218**
C.1.3 Design of expansion joints **218**
C.1.4 Designing with expansion joints **219**
C.1.5 Analyses and calculation **221**
C.1.6 Cold pull **221**

C.2 Maximum spacing for unrestrained axially compensated straight runs **222**
C.2.1 General **222**
C.2.2 Calculation rules **222**
C.2.3 Maximum spacing for specified conditions **223**
C.3 Indication for the design of expansion joints **224**
C.3.1 General **224**
C.3.2 Information for the system analyst **224**

Annex D (normative) **Flanges** **225**
D.1 Purpose **225**
D.2 Specific terms and definitions **225**
D.3 Specific symbols and abbreviations **226**
D.4 General **227**
D.4.1 Introduction **227**
D.4.2 Use of standard flanges without calculation **227**
D.4.3 Bolting **228**
D.4.4 Flange construction **230**
D.4.5 Machining **230**
D.4.6 Gaskets **230**
D.5 Narrow face gasketed flanges **231**
D.5.1 General **231**
D.5.2 Bolt loads and areas **233**
D.5.3 Flange moments **234**
D.5.4 Flange stresses and stress limits **234**
D.5.5 Narrow face flanges subject to external pressure **240**
D.5.6 Lap joints **240**
D.5.7 Split ring flanges **243**
D.6 Full face flanges with soft ring type gaskets **244**
D.6.1 Specific symbols and abbreviations **245**
D.6.2 Bolt loads and areas **245**
D.6.3 Flange design **246**
D.6.4 Full face flanges subject to external pressure **247**
D.7 Seal welded flanges **247**
D.8 Reverse narrow face flanges **248**
D.8.1 Internal pressure **248**
D.8.2 External pressure **250**
D.9 Reverse full face flanges **250**
D.9.1 General **250**
D.9.2 Design following method of D.5 ..... **250**
D.9.3 Design following method of D.6 ..... **252**
D.10 Full face flanges with metal to metal contact **254**
D.10.1 General **254**
D.10.2 Specific symbols and abbreviations **254**
D.10.3 Design **255**

Annex E (normative) **Design of branch connections in piping accessories** **257**
E.1 Scope **257**
E.1.1 General **257**
E.2 Reinforcement **259**
E.2.1 Angles and areas **259**
E.2.2 The following condition shall be satisfied: **259**
E.3 Flexibility analysis **260**

Annex F (informative) **Testing during operation in the case of cyclic loading** **262**
F.1 Testing during operation **262**

F.2 Measures to be taken when the calculated fatigue life has been reached 262

Annex G (informative) **Physical properties of steels 263**
G.1 General 263
G.2 Physical properties 263
G.2.1 Density 263
G.2.2 Differential coefficient of linear expansion 264
G.2.3 Specific thermal capacity 264
G.2.4 Thermal diffusivity 264
G.2.5 Poisson's ratio 264
G.3 Physical properties of steels 264
G.4 Material properties of carbon steel (structural steel) at elevated temperatures 270

Annex H (normative) **Flexibility characteristics, flexibility and stress intensification factors and section moduli of piping components and geometrical discontinuities 271**

Annex I (informative) **Production testing of spring supports and shock arrestors (shock absorbers) 281**
I.1 Constant load supports 281
I.2 Variable spring supports 281
I.3 Shock arrestors 281

Annex J (normative) **Type testing of support components 286**

Annex K (informative) **Attachment of supports to structures 287**
K.1 Attachment of supports to concrete structures 287
K.2 Attachment to metallic structures 288
K.2.1 Standard bolts 288
K.2.2 Friction grip bolts 288
K.2.3 Welding 288

Annex L (informative) **Buckling of linear type supports 289**
L.1 General 289
L.2 Symbols 289
L.3 Basic equations 289
L.4 Allowable compressive stress 290
L.5 Buckling length 290

Annex M (informative) **Design guidance for structural components 293**
M.1 Linear type components subjected to bending 293
M.1.1 General 293
M.1.2 Supplementary verifications for linear type supports 293
M.2 Stability of plate type supports 295
M.3 Anchorage plates or equivalent anchorage components 295
M.3.1 General 295
M.3.2 Design of simple anchorage plates 295
M.3.3 Fixing plates with stiffening gussets 295
M.3.4 Load calculations for anchorages fixed in concrete 296

Annex N (normative) **Documentation of supports 297**

Annex O (normative) **Alternative method for checking branch connections 300**
O.1 Scope 300
O.2 Symbols 300
O.3 Design and checking of the branch connection 302
O.3.1 Limit value for the load due to pressure only for straight pipes without opening 302
O.3.2 Determination of the minimum thicknesses under loading due to pressure only 302

O.3.3 Checking of the thicknesses selected for the combination of pressure loading and loadings due to external loads ... **303**

Annex P (informative) **Recommended gaskets for industrial piping** ... **354**

Annex Q (informative) **Simplified pipe stress analysis** ... **356**
Q.1 General ... **356**
Q.2 Simplified procedure ... **356**
Q.2.1 General ... **356**
Q.2.2 Specification of allowable spacing of supports ... **356**
Q.2.3 Check of elasticity ... **356**
Q.3 Explanatory notes for Table Q.1 ... **358**
Q.4 Symbols ... **360**
Q.5 Indices f_L ... **360**
Q.6 Explanatory notes to Q.2.2 ... **361**
Q.6.1 Specification of allowable spacing of supports ... **361**
Q.7 Conversion of the allowable lengths ... **362**
Q.7.1 Other support conditions ... **362**
Q.7.2 Other parameters ... **362**
Q.8 Additional single loads ... **363**
Q.8.1 General ... **363**
Q.9 Explanatory note on Figure Q.2 ... **366**
Q.9.1 General ... **366**
Q.9.2 Required pipe leg length L_1, for f_1 from the nomogram ... **368**
Q.9.3 Required pipe leg length L_2, for f_2 from the nomogram ... **368**

Annex R (informative) **Surveillance of components operating in the creep range** ... **373**
R.1 General ... **373**
R.2 Recording of operating data ... **373**
R.3 Calculation of the creep exhaustion or the theoretical residual lifetime ... **373**
R.4 Assessment of the cumulated creep ... **375**
R.5 Review and repair of cracks ... **375**
R.6 Creep and fatigue ... **375**
R.7 Measures when reaching certain degrees of exhaustion ... **375**

Annex Y (informative) **History of EN 13480-3** ... **376**
Y.1 Differences between EN 13480-3:2017 and EN 13480-3:2024 ... **376**

Annex ZA (informative) **Relationship between this European Standard and the Essential Requirements of EU Directive 2014/68/EU aimed to be covered** ... **379**

Bibliography ... **381**