

DIN EN 13480-3:2014-12 (E)

Metallic industrial piping - Part 3: Design and calculation

Contents		Page
Foreword.....		9
1	Scope	11
2	Normative references	11
3	Terms, definitions, symbols and units	12
3.1	Terms and definitions	12
3.2	Symbols and units	12
4	Basic design criteria.....	14
4.1	General.....	14
4.2	Loadings	14
4.2.1	General.....	14
4.2.2	Combination of loads	15
4.2.3	Loads for dimensioning	15
4.2.4	Other loads to be taken into account	16
4.2.5	Design conditions.....	18
4.3	Thickness	20
4.4	Tolerances	22
4.5	Joint coefficient	22
4.6	Dimensioning of piping components subject to pressure	22
5	Design stresses	23
5.1	General.....	23
5.2	Time-independent nominal design stress.....	23
5.2.1	Steels other than austenitic steels.....	23
5.2.2	Austenitic steels	23
5.2.3	Nickel and / or chromium alloy steels	24
5.2.4	Steels castings.....	24
5.2.5	Additional requirements for steels with no specific control.....	24
5.3	Time-dependent nominal design stress	25
5.3.1	General.....	25
5.3.2	Steels	25
5.3.3	Nickel and/or chromium alloy steels	26
6	Design of piping components under internal pressure.....	26
6.1	Straight pipes	26
6.2	Pipe bends and elbows	27
6.2.1	General.....	27
6.2.2	Symbols	27
6.2.3	Required wall thicknesses.....	27
6.3	Mitre bends.....	29
6.3.1	General.....	29
6.3.2	Symbols	29
6.3.3	Effective radius of mitre bend	30
6.3.4	Multiple mitre bends	31
6.3.5	Single mitre bends.....	31
6.3.6	Adjacent straight pipe sections of mitre bends	31
6.4	Reducers.....	31
6.4.1	Conditions of applicability	31
6.4.2	Specific definitions	32
6.4.3	Specific symbols and abbreviations.....	32
6.4.4	Conical shells.....	33

6.4.5	Junctions - general.....	34
6.4.6	Junction between the large end of a cone and a cylinder without a knuckle.....	34
6.4.7	Junction between the large end of a cone and a cylinder with a knuckle.....	37
6.4.8	Junction between the small end of a cone and a cylinder.....	38
6.4.9	Offset reducers.....	40
6.4.10	Special forged reducers.....	40
6.5	Flexible piping components.....	41
6.5.1	General.....	41
6.5.2	Expansion joints.....	41
6.5.3	Corrugated metal hose assemblies.....	42
6.6	Bolted flange connections.....	44
6.6.1	General.....	44
6.6.2	Symbols.....	44
6.6.3	Standard flange.....	44
6.6.4	Non-standard flange.....	45
7	Design of ends under internal pressure.....	45
7.1	Dished ends.....	45
7.1.1	Symbols.....	45
7.1.2	Hemispherical ends.....	46
7.1.3	Torispherical ends.....	46
7.1.4	Ellipsoidal ends.....	48
7.1.5	Calculation of β	49
7.2	Circular flat ends.....	52
7.2.1	General.....	52
7.2.2	Symbols.....	52
7.2.3	Unstayed flat circular ends welded to cylindrical shells/pipes.....	54
7.2.4	Unstayed flat circular bolted ends.....	61
7.2.5	Reinforcements of openings in unstayed flat ends.....	67
8	Openings and branch connections.....	69
8.1	General.....	69
8.2	Symbols.....	70
8.3	Limitations.....	71
8.3.1	Thickness ratio.....	71
8.3.2	Openings in the vicinity of discontinuities.....	72
8.3.3	Types of reinforcement.....	74
8.3.4	Calculation method.....	75
8.3.5	Elliptical openings and oblique branch connections.....	75
8.3.6	Reinforcing pads.....	77
8.3.7	Dissimilar material of shell and reinforcements.....	77
8.3.8	Extruded outlets.....	77
8.3.9	Branches in bends or elbows.....	77
8.3.10	Screwed-in branches.....	77
8.4	Isolated openings.....	78
8.4.1	General.....	78
8.4.2	Unreinforced openings.....	81
8.4.3	Reinforced openings with $d_i/D_i < 0,8$	81
8.4.4	Reinforced single openings with $0,8 < d/D \leq 1,0$	87
8.5	Adjacent openings.....	87
8.5.1	Unreinforced openings.....	87
8.5.2	Reinforced openings with $d/D \leq 0,8$	87
8.6	Design of special piping components.....	88
8.6.1	Cylindrical Y-pieces.....	88
8.6.2	Spherical Y-pieces.....	89
8.6.3	Triform reinforced branches.....	90
9	Design of piping components under external pressure.....	91
9.1	General.....	91
9.2	Symbols and elastic stress limits.....	93

9.2.1	Symbols	93
9.2.2	Elastic stress limits	94
9.3	Cylindrical pipes, elbows and mitre bends	94
9.3.1	Determination of lengths	94
9.3.2	Interstiffener collapse	96
9.3.3	Overall collapse of stiffened pipes	98
9.3.4	Stiffener stability.....	99
9.3.5	Heating/cooling channels	102
9.4	Reducers (conical shells)	103
9.5	Dished ends.....	104
9.5.1	Hemispherical ends.....	104
9.5.2	Torispherical ends.....	105
9.5.3	Ellipsoidal ends.....	105
10	Design for cyclic loading	106
10.1	General.....	106
10.2	Exemption from detailed fatigue analysis.....	106
10.3	Fatigue design for cyclic pressure	107
10.3.1	Equivalent full load cycles.....	107
10.3.2	Simplified fatigue analysis.....	107
10.4	Fatigue design for thermal gradients	121
10.4.1	General.....	121
10.4.2	Design guidance	121
10.5	Fatigue design for combined loads	121
11	Integral attachments.....	122
11.1	General.....	122
11.2	Allowable stresses.....	122
11.3	Symbols	123
11.4	Hollow circular attachments.....	125
11.4.1	Limitations	125
11.4.2	Preliminary calculations	125
11.4.3	Analysis of attachments welded to pipe with a full penetration weld.....	127
11.4.4	Analysis of attachments welded to pipe with fillet or partial penetration weld	128
11.5	Rectangular attachments.....	128
11.5.1	Limitations.....	128
11.5.2	Preliminary calculations	128
11.5.3	Analysis of attachments welded to pipe with a full penetration weld.....	130
11.5.4	Analysis of attachments welded to pipe with fillet or partial penetration weld	130
11.6	Stress analysis of the run pipe.....	131
11.7	Shear stress analysis in attachment.....	132
11.7.1	Hollow circular attachments.....	132
11.7.2	Rectangular attachments.....	133
11.8	Alternative calculation methods	133
12	Flexibility analysis and acceptance criteria.....	133
12.1	Basic conditions	133
12.1.1	General.....	133
12.1.2	Loading conditions.....	133
12.1.3	Allowable stresses.....	133
12.2	Piping flexibility	135
12.2.1	General.....	135
12.2.2	Basic conditions	135
12.2.3	Displacement strains.....	136
12.2.4	Displacement stresses.....	137
12.2.5	Stress range	137
12.2.6	Cold pull.....	138
12.2.7	Properties for flexibility analysis	138
12.2.8	Supporting conditions	139
12.2.9	Expansion joints	140

12.2.10	Flexibility analysis	140
12.3	Flexibility analysis	142
12.3.1	General	142
12.3.2	Stress due to sustained loads	142
12.3.3	Stress due to sustained and occasional or exceptional loads	143
12.3.4	Stress range due to thermal expansion and alternating loads	144
12.3.5	Additional conditions for the creep range	145
12.3.6	Stresses due to a single non-repeated support movement	145
12.3.7	Determination of resultant moments	145
12.3.8	Reactions	148
12.4	Fatigue analysis	148
12.5	Vibration	148
13	Supports	148
13.1	General requirements	148
13.1.1	General	148
13.1.2	Classification of supports	149
13.1.3	Additional definitions	149
13.1.4	Boundaries	150
13.1.5	Welded support attachments	152
13.2	Material requirements	154
13.3	Design	154
13.3.1	General	154
13.3.2	Design temperatures for support components	155
13.3.3	Detail design	157
13.3.4	Buckling	158
13.3.5	Support location	158
13.3.6	Determination of component sizes	158
13.4	Connections	159
13.4.1	Welded connections	159
13.4.2	Bolted connections	160
13.5	Design requirements for special components	160
13.5.1	Constant load hangers and supports	160
13.5.2	Variable load hangers and supports	161
13.5.3	Rigid struts	162
13.5.4	Shock arrestors (shock absorber, snubber)	163
13.5.5	Sliding supports	164
13.5.6	Anchors	164
13.6	Documentation of supports	164
13.7	Marking of supports	164
Annex A	(informative) Dynamic analysis	165
A.1	General	165
A.2	Analysis by calculation	165
A.2.1	Seismic events	165
A.2.2	Rapid valve closure	169
A.2.3	Flow induced vibration	172
A.2.4	Safety valve discharge	174
A.2.5	Allowable stresses	176
A.3	Alternative means of design verification	176
A.3.1	Comparative studies	176
A.3.2	Full scale testing	177
A.3.3	Reduced scale testing	177
Annex B	(normative) More accurate calculation of bends and elbows	178
B.1	General	178
B.2	Symbols and units	178
B.3	Required wall thickness	179
B.4	Calculation	180
B.4.1	Calculation of wall thickness	180

B.4.2	Stress calculation	182
Annex C	(informative) Expansion joints	186
C.1	Incorporation of expansion joints into piping systems	186
C.1.1	General	186
C.1.2	Types of expansion joints	186
C.1.3	Design of expansion joints	187
C.1.4	Designing with expansion joints	188
C.1.5	Analyses and calculation	189
C.1.6	Cold pull	190
C.2	Maximum spacing for unrestrained axially compensated straight runs	190
C.2.1	General	190
C.2.2	Calculation rules	190
C.2.3	Maximum spacing for defined conditions	192
C.3	Indication for the design of expansion joints	193
C.3.1	General	193
C.3.2	Design data, Symbols	194
C.3.3	Design and calculation	195
C.3.4	Information for the system analyst	197
Annex D	(normative) Flanges	198
D.1	Purpose	198
D.2	Specific terms and definitions	198
D.3	Specific symbols and abbreviations	199
D.4	General	200
D.4.1	Introduction	200
D.4.2	Use of standard flanges without calculation	201
D.4.3	Bolting	201
D.4.4	Flange construction	203
D.4.5	Machining	203
D.4.6	Gaskets	203
D.5	Narrow face gasketed flanges	204
D.5.1	General	204
D.5.2	Bolt loads and areas	207
D.5.3	Flange moments	208
D.5.4	Flange stresses and stress limits	209
D.5.5	Narrow face flanges subject to external pressure	215
D.5.6	Lap joints	215
D.5.7	Split ring flanges	218
D.6	Full face flanges with soft ring type gaskets	219
D.6.1	Specific symbols and abbreviations	220
D.6.2	Bolt loads and areas	220
D.6.3	Flange design	221
D.6.4	Full face flanges subject to external pressure	222
D.7	Seal welded flanges	222
D.8	Reverse narrow face flanges	223
D.8.1	Internal pressure	223
D.8.2	External pressure	225
D.9	Reverse full face flanges	225
D.9.1	General	225
D.9.2	Design following method of D.5	225
D.9.3	Design following method of D.6	227
D.10	Full face flanges with metal to metal contact	229
D.10.1	General	229
D.10.2	Specific symbols and abbreviations	229
D.10.3	Design	230
Annex E	(normative) Design of branch connections in piping accessories	232
E.1	Scope	232
E.1.1	General	232

E.2	Reinforcement	234
E.2.1	Angles and areas	234
E.2.2	The following condition shall be satisfied:	234
E.3	Flexibility analysis	236
Annex F	(informative) Testing during operation in the case of cyclic loading	237
F.1	Testing during operation	237
F.2	Measures to be taken when the calculated fatigue life has been reached	237
Annex G	(informative) Physical properties of steels	238
G.1	General	238
G.2	Physical properties	238
G.2.1	Density	238
G.2.2	Differential coefficient of linear expansion	239
G.2.3	Specific thermal capacity	239
G.2.4	Thermal diffusivity	239
G.2.5	Poisson's ratio	239
G.3	Physical properties of steels	239
Annex H	(normative) Flexibility characteristics, flexibility and stress intensification factors and section moduli of piping components and geometrical discontinuities	245
Annex I	(informative) Production testing of spring supports and shock arrestors (shock absorbers)	255
I.1	Constant load supports	255
I.2	Variable spring supports	255
I.3	Shock arrestors	255
Annex J	(normative) Type testing of support components	260
Annex K	(informative) Attachment of supports to structures	261
K.1	Attachment of supports to concrete structures	261
K.2	Attachment to metallic structures	262
K.2.1	Standard bolts	262
K.2.2	Friction grip bolts	262
K.2.3	Welding	262
Annex L	(informative) Buckling of linear type supports	263
L.1	General	263
L.2	Symbols	263
L.3	Basic formulae	264
L.4	Allowable compressive stress	264
L.5	Buckling length	265
Annex M	(informative) Design guidance for structural components	267
M.1	Linear type components subjected to bending	267
M.1.1	General	267
M.1.2	Supplementary verifications for linear type supports	267
M.2	Stability of plate type supports	269
M.3	Anchorage plates or equivalent anchorage components	269
M.3.1	General	269
M.3.2	Design of simple anchorage plates	269
M.3.3	Fixing plates with stiffening gussets	270
M.3.4	Load calculations for anchorages fixed in concrete	270
Annex N	(normative) Documentation of supports	271
Annex O	(normative) Alternative method for checking branch connections	273
O.1	Scope	273
O.2	Symbols	273
O.3	Design and checking of the branch connection	275
O.3.1	Limit value for the load due to pressure only for straight pipes without opening	275
O.3.2	Determination of the minimum thicknesses under loading due to pressure only	276

O.3.3	Checking of the thicknesses selected for the combination of pressure loading and loadings due to external loads	276
Annex P	(informative) Bolted flange connections — Application of EN 1591	327
P.1	Introduction	327
P.2	Scope	328
P.2.1	General.....	328
P.2.2	Materials	328
P.2.3	Loadings	328
P.2.4	Assumptions	328
P.3	Application of EN 1591	329
P.3.1	Calculations.....	329
P.3.2	Gasket coefficients.....	329
P.3.3	Tightening.....	330
Annex Q	(informative) Simplified pipe stress analysis	389
Q.1	General.....	389
Q.2	Simplified procedure	389
Q.2.1	General.....	389
Q.2.2	Specification of allowable spacing of supports	389
Q.2.3	Check of elasticity	389
Q.3	Explanatory notes for Table Q.1.....	391
Q.4	Symbols	393
Q.5	Indices f_L	393
Q.6	Explanatory notes to Q.2.2	394
Q.6.1	Specification of allowable spacing of supports	394
Q.7	Conversion of the allowable lengths	395
Q.7.1	Other support conditions.....	395
Q.7.2	Other parameters	395
Q.8	Additional single loads	396
Q.8.1	General.....	396
Q.9	Explanatory note on Figure Q.2	399
Q.9.1	General.....	399
Q.9.2	Required pipe leg length L_1 , for f_1 from the nomogram.....	401
Q.9.3	Required pipe leg length L_2 , for f_2 from the nomogram.....	401
Annex Y	(informative) History of EN 13480-3	406
Annex ZA	(informative) Relationship between this European Standard and the essential requirements of EU Directive 97/23/EC	407
Bibliography	408