

# DIN EN 13480-3:2012-11 (E)

## Metallic industrial piping - Part 3: Design and calculation

---

<b>Contents</b>		<b>Page</b>
Foreword .....		9
<b>1</b>	<b>Scope .....</b>	<b>11</b>
<b>2</b>	<b>Normative references .....</b>	<b>11</b>
<b>3</b>	<b>Terms, definitions, symbols and units .....</b>	<b>12</b>
3.1	Terms and definitions .....	12
3.2	Symbols and units .....	12
<b>4</b>	<b>Basic design criteria .....</b>	<b>14</b>
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
<b>5</b>	<b>Design stresses .....</b>	<b>23</b>
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
<b>6</b>	<b>Design of piping components under internal pressure .....</b>	<b>26</b>
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
Issue 1 (2012-06)	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 .....	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
Issue 1 (2012-06)	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

Issue 1 (2012-06) 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
Issue 1 (2012-06)	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
Issue 1 (2012-06)	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
Issue 1 (2012-06) 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 fL .....	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 L1, for f1 from the nomogram .....	401
Q.9.3	Required pipe leg length L2, for f2 from the nomogram .....	401
Y.1	Differences between EN 13480:2002 and EN 13480:2012 .....	406
Annex ZA (informative) Relationship between this European Standard and the essential requirements of EU Directive 97/23/EC .....		407
Bibliography .....		408