

DIN EN 13445-3:2011-12 (E)

Unfired pressure vessels - Part 3: Design

Contents		Page
Foreword.....		6
1	Scope	7
2	Normative references	7
3	Terms and definitions	8
4	Symbols and abbreviations	10
5	Basic design criteria.....	12
5.1	General.....	12
5.2	Corrosion, erosion and protection.....	12
5.3	Load cases	14
5.4	Design methods	18
5.5	Thickness calculations (DBF).....	19
5.6	Joint coefficient	20
5.7	Design requirements of welded joints.....	21
6	Maximum allowed values of the nominal design stress for pressure parts.....	24
6.1	General.....	24
6.2	Steels (except castings), other than austenitic steels covered by 6.4 and 6.5, with a minimum rupture elongation, as given in the relevant technical specification for the material, below 30 % ²⁵	
6.3	Alternative route for steels (except castings), other than austenitic steels covered by 6.4 and 6.5, with a minimum rupture elongation, as given in the relevant technical specification for the material, below 30 %.....	25
6.4	Austenitic steels (except castings) with a minimum elongation after rupture, as given in the relevant technical specification for the material, from 30 % to 35 %	26
6.5	Austenitic steels (except castings) with a minimum rupture elongation, as given in the relevant technical specification for the material, from 35 %.....	26
6.6	Cast steels	27
7	Shells under internal pressure	28
7.1	Purpose.....	28
7.2	Specific definitions.....	28
7.3	Specific symbols and abbreviations.....	28
7.4	Cylindrical and spherical shells	28
7.5	Dished ends.....	29
7.6	Cones and conical ends.....	34
7.7	Nozzles which encroach into the knuckle region.....	42
8	Shells under external pressure	47
8.1	Purpose.....	47
8.2	Specific definitions.....	47
8.3	Specific symbols and definitions.....	47
8.4	General.....	50
8.5	Cylindrical shells	51
8.6	Conical shell.....	72
8.7	Spherical shells.....	80
8.8	Vessel ends	81
9	Openings in shells	82
9.1	Purpose.....	82
9.2	Specific definitions.....	82
9.3	Specific symbols and abbreviations.....	83
9.4	General.....	86
9.5	Isolated openings	98
9.6	Multiple openings	114
9.7	Openings close to a shell discontinuity	124

10	Flat ends	132
10.1	Purpose.....	132
10.2	Specific definitions.....	132
10.3	Specific symbols and abbreviations	132
10.4	Unpierced circular flat ends welded to cylindrical shells	134
10.5	Unpierced bolted circular flat ends	141
10.6	Pierced circular flat ends.....	145
10.7	Flat ends of non-circular or annular shape.....	149
11	Flanges	153
11.1	Purpose.....	153
11.2	Specific definitions.....	153
11.3	Specific symbols and abbreviations	153
11.4	General.....	156
11.5	Narrow face gasketed flanges.....	160
11.6	Full face flanges with soft ring type gaskets.....	175
11.7	Seal welded flanges.....	178
11.8	Reverse narrow face flanges.....	178
11.9	Reverse full face flanges.....	181
11.10	Full face flanges with metal to metal contact	185
12	Bolted domed ends	188
12.1	Purpose.....	188
12.2	Specific definitions.....	188
12.3	Specific symbols and abbreviations	188
12.4	General.....	188
12.5	Bolted domed ends with narrow face gaskets	188
12.6	Bolted domed ends with full face joints.....	190
13	Heat Exchanger Tubesheets	192
13.1	Purpose.....	192
13.2	Specific definitions.....	192
13.3	Specific symbols and abbreviations	192
13.4	U-tube tubesheet heat exchangers.....	195
13.5	Fixed tubesheet heat exchangers.....	209
13.6	Floating tubesheet heat exchangers	237
13.7	Tubesheet characteristics	254
13.8	Maximum permissible tube to tubesheet joint stress.....	261
13.9	Maximum permissible longitudinal compressive stress for tubes	262
13.10	Design of tubesheet flange extension with a narrow face gasket.....	265
13.11	Design of tubesheet flange extension with a full face gasket	268
13.12	Special tube-to-tubesheet welded joints.....	271
14	Expansion bellows	274
14.1	Purpose.....	274
14.2	Specific definitions.....	274
14.3	Specific symbols and abbreviations	276
14.4	Conditions of applicability.....	278
14.5	U-shaped unreinforced bellows	280
14.6	U-shaped reinforced bellows	294
14.7	Toroidal bellows	302
14.8	Fabrication	309
14.9	Inspection and testing.....	311
14.10	Bellows subjected to axial, lateral or angular displacements	313
15	Pressure vessels of rectangular section.....	318
15.1	Purpose.....	318
15.2	Specific definitions.....	318
15.3	Specific symbols and abbreviations	318
15.4	General.....	319
15.5	Unreinforced vessels	319
15.6	Reinforced vessels	325
15.7	Openings	332

16	Additional non-pressure loads.....	334
16.1	Purpose.....	334
16.2	Specific definitions.....	334
16.3	Specific symbols and abbreviations.....	335
16.4	Local loads on nozzles in spherical shells	336
16.5	Local loads on nozzles in cylindrical shells	346
16.6	Line loads	354
16.7	Lifting lugs.....	360
16.8	Horizontal vessels on saddle supports.....	364
16.9	Horizontal vessels on ring supports.....	378
16.10	Vertical vessels on bracket supports	383
16.11	Vertical vessels with supporting legs	388
16.12	Vertical vessels with skirts	390
16.13	Vertical vessels with ring supports	405
16.14	Global loads	415
17	Simplified assessment of fatigue life.....	420
17.1	Purpose.....	420
17.2	Specific definitions.....	420
17.3	Specific symbols and abbreviations.....	422
17.4	Conditions of applicability	423
17.5	General.....	424
17.6	Determination of allowable number of pressure cycles.....	424
17.7	Assessment rule	450
17.8	Design and manufacture	450
17.9	Testing	451
18	Detailed assessment of fatigue life.....	452
18.1	Purpose.....	452
18.2	Specific definitions.....	452
18.3	Specific symbols and abbreviations.....	455
18.4	Limitations.....	457
18.5	General.....	459
18.6	Welded material	461
18.7	Unwelded components and bolts	466
18.8	Elastic-plastic conditions	469
18.9	Fatigue action.....	471
18.10	Fatigue strength of welded components	474
18.11	Fatigue strength of unwelded components	495
18.12	Fatigue strength of steel bolts	500
19	Creep design	503
19.1	Purpose.....	503
19.2	Specific definitions.....	503
19.3	Specific symbols and abbreviations.....	503
19.4	Design in the creep range.....	504
19.5	Nominal Design stress in the creep range.....	504
19.6	Weld joint factor in the creep range.....	509
19.7	Pressure loading of predominantly non-cyclic nature in the creep range	509
19.8	Design procedures for DBF	509
20	Design rules for reinforced flat walls.....	513
20.1	General.....	513
20.2	Stayed flat walls.....	513
20.3	Specific definitions for stayed flat walls	513
20.4	Required thickness of stayed flat walls	513
20.5	Required dimensions and layout of staybolts and stays	513
20.6	Requirements for threaded staybolts.....	513
20.7	Requirements for welded-in staybolts and welded stays	514
20.8	Tables for stayed flat walls	515
20.9	Figures for Stayed Flat Walls	516
21	Circular flat ends with radial reinforcement ribs.....	519
21.1	Purpose.....	519

21.2	Specific definitions.....	519
21.3	Specific symbols and abbreviations	521
21.4	Ends without additional peripheral bending moment	522
21.5	Ends with additional peripheral bending moment	524
21.6	Openings	526
21.7	Welds	526
21.8	Central Ring	527
Annex A	(normative) Design requirements for pressure bearing welds	528
Annex B	(normative) Design by Analysis – Direct Route.....	552
Annex C	(normative) Design by analysis - Method based on stress categories	582
Annex D	(informative) Verification of the shape of vessels subject to external pressure	601
Annex E	(normative) Procedure for calculating the departure from the true circle of cylinders and cones.....	608
Annex F	(normative) Allowable external pressure for vessels outside circularity tolerance.....	611
Annex G	(normative) Alternative design rules for flanges and gasketed flange connections.....	613
Annex GA	(informative) Alternative design rules for flanges and gasketed flange connections.....	660
Annex H	(informative) Gasket factors <i>m</i> and <i>y</i>	723
Annex I	(informative) Additional information on heat exchanger tubesheet design.....	726
Annex J	(normative) Alternative method for the design of heat exchanger tubesheets	730
Annex K	(informative) Additional information on expansion bellows design	775
Annex L	(informative) Basis for design rules related to additional non-pressure loads	781
Annex M	(informative) In service monitoring of vessels operating in fatigue or creep.....	783
Annex N	(informative) Bibliography to clause 18.....	786
Annex O	(informative) Physical properties of steels	787
Annex P	(normative) Classification of weld details to be assessed using principal stresses.....	795
Annex Q	(normative) Simplified procedure for the fatigue assessment of unwelded zones	808
Annex R	(informative) Coefficients for creep-rupture model equations for extrapolation of creep- rupture strength.....	809
Annex S	(informative) Extrapolation of the nominal design stress based on time-independent behaviour in the creep range	813
Annex T	(normative) Design by experimental methods	819
Annex Y	(informative) History of EN 13445-3	832
Annex ZA	(informative) Relationship between this European Standard and the Essential Requirements of the EU Pressure Equipment Directive 97/23/EC	833