

DIN EN 13445-3:2010-02 (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
Issue 1 (2009-07) 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
Issue 1 (2009-07)	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
Issue 1 (2009-07)	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 m and y	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 ZA (informative) Relationship between this European Standard and the Essential Requirements of the EU Pressure Equipment Directive 97/23/EC	833