

DIN EN 13121-3:2010-06 (E)

GRP tanks and vessels for use above ground - Part 3: Design and workmanship (includes Amendment A1:2010)

Contents		Page
Foreword		6
Introduction		7
1	Scope	8
2	Normative references	8
3	Terms and definitions	10
4	Symbols and abbreviations	11
5	Information and requirements to be supplied and to be documented	14
5.1	General	14
5.2	Information to be obtained by the manufacturer	14
5.3	Information to be prepared by the manufacturer	14
5.4	Final documentation	15
6	Material	15
6.1	General	15
6.2	Chemical protective barrier	15
6.3	Flammability	16
6.4	Electrical resistivity	16
7	Mechanical properties	17
7.1	General	17
7.2	Heat deflection temperature	17
7.3	Laminate construction	17
7.4	Lamina thickness	19
7.5	Laminate properties	19
7.6	Inter-laminar shear strength	19
7.7	Peel strength	20
7.8	Selection of physical properties of materials and allowable design factors	20
8	Determination of design strain and loadings	25
8.1	General	25
8.2	Allowable design strains	25
8.3	Laminate design loadings	26
8.4	Laminate design	26
8.5	Laminate thickness	27
9	Design	28
9.1	Introduction	28
9.2	Determination of external loads	29
9.3	Drawings and design calculations	30
9.4	Design details	30
10	Design analysis	31
10.1	Symbols and units	31
10.2	Vertical vessels or tanks, cylinders under loads ($t < 0,01 D$)	32
10.3	Cylindrical shells subject to compressive loadings -- critical buckling criteria	34

10.4	Conical shells	39
10.5	Dished end	45
10.6	Flat circular ends	47
10.7	Circumferential seams	58
10.8	Openings, branches and compensating laminate	61
10.9	Flat panels	70
10.10	Rectangular tanks	81
10.11	Horizontal vessels	83
11	Bolted flange connections	99
11.1	General	99
11.2	Full faced flanges (with full faced gaskets) design	106
11.3	Stub flange design with metallic backing ring	110
11.4	Preformed flanges	113
11.5	Butt and strap jointed flanges	114
11.6	Stub flange design with non-metallic backing ring	114
12	Supports	115
12.1	General	115
12.2	Vertical tanks	115
12.3	Supports and mountings for vessels	115
12.4	Seismic loading	121
12.5	Design calculation for tank and vessel anchorage	121
13	Structures and fittings	123
13.1	General	123
13.2	Internal structures and fittings	123
13.3	External structures and fittings	123
13.4	Lifting devices	123
14	Local load analysis	124
14.1	General	124
14.2	Symbols	124
14.3	Calculation of force and moment resultants	124
14.4	Calculation of laminate strains	124
15	Quality control	125
15.1	General	125
15.2	Works requirements	125
15.3	Documentation to be prepared by the manufacturer	126
15.4	Manufacture	133
15.5	Inspection and testing after completion of fabrication	135
15.6	Experimental design verification method	136
16	Site built tanks and vessels	138
16.1	General	138
16.2	Design	138
16.3	Manufacture	139
16.4	Inspection	139
17	Marking	139
Annex A (informative) Product testing for volume or batch production process		141
A.1	Initial type testing (ITT)	141
A.2	Testing of samples	141
A.3	Inspection and test records	143
Annex B (informative) Derivation of laminate properties from lamina properties		144
B.1	General	144
B.2	Lamina/laminate thickness	144

B.3	Laminate modulus	145
B.4	Determination of laminate flexural stiffness	146
B.5	Determination of laminate strains from load resultants	146
Annex C (normative) Pressure and leak testing		148
C.1	General	148
C.2	Open top tanks and containers	148
C.3	Closed tanks and vessels	149
C.4	Hydraulic pressure test	149
Annex D (normative) Methods of tests		150
D.1	General	150
D.2	Loss on ignition	151
D.3	Tensile strength of thermoplastics welds	151
D.4	Bend tests for welds in thermoplastics	151
D.5	Ultimate tensile unit strength of laminates	153
D.6	Unit tensile modulus of laminates	154
D.7	Inter laminar shear strength of laminates	156
D.8	Lap shear strength of bond between thermoplastics lining and laminate or between laminates	157
D.9	Peel strength of bond between laminate layers	160
D.10	Flexural short term creep test	160
D.11	Barcol hardness	163
D.12	Determination of electrical resistivity	163
D.13	Residual styrene polyester resins	163
D.14	Acetone test polyester resins	163
D.15	Spark testing of thermoplastics welds	163
D.16	Long term flexural creep test	164
D.17	Hardness of rubber	166
D.18	Flash point test	166
D.19	Heat deflection temperature test	166
D.20	Flexural strength of laminate	166
Annex E (normative) Approval testing of laminators		167
E.1	General	167
E.2	Assessment of the laminator	167
E.3	Procedure	167
E.4	Test pieces	168
E.5	Evaluation of test pieces	168
E.6	Minimum requirements for acceptance	169
E.7	Test certificate	169
E.8	Validity and renewal	169
E.9	Range of approval	170
Annex F (normative) Approval testing of welders		171
F.1	General	171
F.2	Test requirements	172
F.3	Procedure	172
F.4	Test pieces	173
F.5	Evaluation of test pieces	173
F.6	Minimum requirements for acceptance	174
F.7	Test certificate	174
F.8	Validity and renewal	174
F.9	Range of approval	174
Annex G (informative) Loading from local loads - Methods of calculation		176
G.1	General	176

G.2	Local loads on pressure vessel shells	176
	Annex H (informative) Design method for filament wound laminates	203
H.1	General	203
H.2	Filament wound laminate properties	204
H.3	Design methods	206
H.4	Axial instability	209
	Annex I (normative) Pre-moulded flanges technical requirements	215
I.1	General	215
	Annex J (informative) Shells subjected to wind loading value from metallic codes	217
J.1	Symbols	217
	Annex K (informative) Horizontal vessel design	222
K.1	General	222
K.2	Strain modification for vessels on rigid saddle support	222
K.3	Horizontal vessels supported on two longitudinal continuous beams	226
	Annex ZA (informative) Relationship between this European Standard and the Essential Requirements of EU Directive 97/23/EC	231
	Bibliography	232