

DIN EN 13445-4:2024-03 (E)

Unfired pressure vessels - Part 4: Fabrication (includes Amendment A1:2023)

Contents	Page
European foreword.....	5
1 Scope.....	7
2 Normative references.....	7
3 Terms and definitions	8
4 Requirements for manufacturing and subcontracting.....	8
4.1 Manufacturing.....	8
4.2 Subcontracting.....	9
5 Materials.....	9
5.1 General.....	9
5.2 Material traceability	9
5.2.1 General.....	9
5.2.2 Identification system	9
5.2.3 Visibility.....	10
5.2.4 Review of material certification and material identification	10
5.2.5 Transfer of markings	10
6 Manufacturing tolerances.....	11
6.1 Surface geometry of welds.....	11
6.2 Middle line alignment.....	11
6.3 Surface alignment	13
6.3.1 Surface misalignment between parts	13
6.3.2 Joining of parts of different thickness	13
6.4 Tolerances for vessels subjected to internal pressure.....	13
6.4.1 External diameter	13
6.4.2 Out of roundness	13
6.4.3 Deviation from the longitudinal axis	14
6.4.4 Irregularities in profile	14
6.4.5 Local thinning.....	16
6.4.6 Dished ends.....	17
6.5 Tolerances for vessels subjected to external pressure	20
6.6 Structural tolerances	20
7 Weld details.....	20
7.1 General.....	20
7.2 Vessels or parts made of more than one course	20
7.3 Lapped joints, joggle joints, permanent backing strips	20
8 Welding.....	20
8.1 General.....	20
8.2 Welding procedure specification (WPS).....	21
8.3 Welding procedure qualification record (WPQR).....	21
8.4 Qualification of welders and welding operators	22
8.5 Filler metals and auxiliary materials.....	23
8.6 Joint preparation.....	23
8.7 Execution of welded joints.....	24
8.8 Attachments, supports and stiffeners.....	24

8.9	Preheat	24
8.10	Permanent joints other than welding	24
8.10.1	General	24
8.10.2	Mechanical roller expansion	25
8.10.3	Brazing.....	25
9	Manufacture and testing of welds — Production test	25
9.1	General	25
9.2	Reference criteria.....	26
9.3	Extent of testing.....	30
9.4	Performance of tests and acceptance criteria.....	32
9.4.1	General	32
9.4.2	Transverse tensile test	32
9.4.3	Longitudinal weld tensile test.....	32
9.4.4	Impact test.....	32
9.4.5	Bend test	32
9.4.6	Macro examination	33
9.4.7	Micro examination	33
9.4.8	Hardness test.....	33
9.4.9	Retests	33
9.4.10	Test report	34
10	Forming of pressure parts.....	34
10.1	General	34
10.2	Ratio of deformation	34
10.2.1	Dished circular products	34
10.2.2	Cylinders and cones made by rolling.....	35
10.2.3	Other product types.....	36
10.2.4	Tube bends.....	37
10.2.5	Forming of Segments.....	37
10.3	Forming procedures	38
10.3.1	Cold forming.....	38
10.3.2	Hot forming.....	39
10.4	Heat treatment after forming.....	41
10.4.1	General	41
10.4.2	Heat treatment of flat products after cold forming.....	41
10.4.3	Heat treatment of tubular products after cold forming.....	42
10.4.4	Heat treatment of clad steels after cold forming.....	43
10.4.5	Heat treatment after hot forming	43
10.4.6	Heat treatment of clad steels after hot forming	44
10.5	Sampling of formed test coupons.....	44
10.5.1	Cold formed products without heat treatment.....	44
10.5.2	Hot formed or cold formed products with heat treatment.....	44
10.6	Tests	45
10.6.1	Base material	45
10.6.2	Butt welds.....	45
10.6.3	Acceptance criteria for formed test coupons	46
10.6.4	Retests of formed coupons	46
10.7	Visual inspection and control of dimension	47
10.8	Marking	47
10.9	Documentation	47
11	Post weld heat treatment (PWHT)	47
11.1	General	47
11.2	Heat treatment conditions	48

11.3	Method of PWHT.....	51
11.4	PWHT procedure.....	52
11.5	Mechanical properties after heat treatment.....	53
11.6	Dissimilar ferritic joints	55
11.7	Special materials	56
11.8	Heat Treatment for reasons other than welding.....	56
12	Repairs	56
12.1	Repairs of surface defects in the parent metal.....	56
12.2	Repair of weld defects	57
13	Finishing operations	57
Annex A (informative) Structural tolerances.....		59
Annex B (informative) Example of a sub-contractors form		63
Annex C (normative) Specification and approval of expansion procedures and operators		64
C.1	General.....	64
C.1.1	Introduction.....	64
C.1.2	Responsibility.....	64
C.1.3	Specification of expansion procedures	64
C.1.4	Technical content of expansion procedure specification (EPS).....	65
C.1.5	Expansion procedure qualification test (EPQT)	66
C.2	Examination and testing.....	66
C.2.1	General.....	66
C.2.2	Visual examination.....	66
C.2.3	Dimensional verification.....	66
C.2.4	Testing.....	67
C.3	Range of approval	67
C.3.1	General.....	67
C.3.2	Manufacturer	67
C.3.3	Material.....	67
C.3.4	Tube dimensions	68
C.3.5	Expansion factor	68
C.3.6	Joint design.....	68
C.3.7	Tool.....	68
C.3.8	PWHT.....	68
C.4	Expansion Procedure Approval Record (EPAR)	69
C.5	Expansion operator approval.....	69
C.5.1	General.....	69
C.5.2	Validity range of expansion operator qualification.....	69
C.5.3	Qualification tests	69
C.5.4	Examination and testing.....	70
C.5.5	Period of validity	70
C.5.6	Certification.....	70
Annex Y (informative) History of EN 13445-4		71
Y.1	Differences between EN 13445-4:2014 and EN 13445-4:2021	71
Annex ZA (informative) Relationship between this European Standard and the essential requirements of Directive 2014/68/EU aimed to be covered.....		72
Bibliography.....		73