

DIN EN 13445-4:2016-12 (E)

Unfired pressure vessels - Part 4: Fabrication

Contents		Page
Foreword		5
1	Scope	7
2	Normative references	7
3	Requirements for manufacturing and subcontracting	9
3.1	Manufacturing	9
3.2	Subcontracting	9
4	Materials	10
4.1	General	10
4.2	Material traceability	10
4.2.1	General	10
4.2.2	Identification system	10
4.2.3	Visibility	11
4.2.4	Review of material certification and material identification	11
4.2.5	Transfer of markings	11
5	Manufacturing tolerances	11
5.1	Surface geometry of welds	11
5.2	Middle line alignment	11
5.3	Surface alignment	13
5.3.1	Surface misalignment between parts	13
5.3.2	Joining of parts of different thickness	13
5.4	Tolerances for vessels subjected to internal pressure	13
5.4.1	External diameter	13
5.4.2	Out of roundness	13
5.4.3	Deviation from the longitudinal axis	14
5.4.4	Irregularities in profile	14
5.4.5	Local thinning	16
5.4.6	Dished ends	17
5.5	Tolerances for vessels subjected to external pressure	19
5.6	Structural tolerances	19
6	Weld details	19
6.1	General	19
6.2	Vessels or parts made of more than one course	19
6.3	Lapped joints, joggle joints, permanent backing strips	19
7	Welding	19
7.1	General	19
7.2	Welding procedure specification (WPS)	20
7.3	Welding procedure qualification record (WPQR)	20
7.4	Qualification of welders and welding operators	21
7.5	Filler metals and auxiliary materials	21
7.6	Joint preparation	21
7.7	Execution of welded joints	22
7.8	Attachments, supports and stiffeners	22
7.9	Preheat	23
7.10	Permanent joints other than welding	23
7.10.1	General	23

7.10.2	Mechanical roller expansion	23
7.10.3	Brazing	23
8	Manufacture and testing of welds -- Production test	23
8.1	General	23
8.2	Reference criteria	24
8.3	Extent of testing	27
8.4	Performance of tests and acceptance criteria	29
8.4.1	General	29
8.4.2	Transverse tensile test	29
8.4.3	Longitudinal weld tensile test	29
8.4.4	Impact test	29
8.4.5	Bend test	29
8.4.6	Macro examination	30
8.4.7	Micro examination	30
8.4.8	Hardness test	30
8.4.9	Retests	30
8.4.10	Test report	31
9	Forming of pressure parts	31
9.1	General	31
9.2	Ratio of deformation	31
9.2.1	Dished circular products	31
9.2.2	Cylinders and cones made by rolling	32
9.2.3	Other product types	33
9.2.4	Tube bends	34
9.2.5	Forming of Segments	34
9.3	Forming procedures	35
9.3.1	Cold forming	35
9.3.2	Hot forming	35
9.4	Heat treatment after forming	38
9.4.1	General	38
9.4.2	Heat treatment of flat products after cold forming	38
9.4.3	Heat treatment of tubular products after cold forming	40
9.4.4	Heat treatment of clad steels after cold forming	40
9.4.5	Heat treatment after hot forming	40
9.4.6	Heat treatment of clad steels after hot forming	41
9.5	Sampling of formed test coupons	41
9.5.1	Cold formed products without heat treatment	41
9.5.2	Hot formed or cold formed products with heat treatment	41
9.6	Tests	42
9.6.1	Base material	42
9.6.2	Butt welds	42
9.6.3	Acceptance criteria for formed test coupons	43
9.6.4	Retests of formed coupons	43
9.7	Visual inspection and control of dimension	43
9.8	Marking	44
9.9	Documentation	44
10	Post weld heat treatment (PWHT)	44
10.1	General	44
10.2	Heat treatment conditions	45
10.3	Method of PWHT	49
10.4	PWHT procedure	50
10.5	Mechanical properties after heat treatment	50
10.6	Dissimilar ferritic joints	51
10.7	Special materials	52
10.8	Heat Treatment for reasons other than welding	52
11	Repairs	53
11.1	Repairs of surface defects in the parent metal	53

11.2	Repair of weld defects	53
12	Finishing operations	53
Annex A (informative) Structural tolerances		55
Annex B (informative) Example of a sub-contractors form		59
Annex C (normative) Specification and approval of expansion procedures and operators		60
C.1	General	60
C.1.1	Introduction	60
Issue 3 (2016-07) C.1.2 Responsibility		60
C.1.3	Specification of expansion procedures	60
C.1.4	Technical content of expansion procedure specification (EPS)	61
C.1.5	Expansion procedure qualification test (EPQT)	62
C.2	Examination and testing	62
C.2.1	General	62
C.2.2	Visual examination	62
C.2.3	Dimensional verification	62
C.2.4	Testing	63
C.3	Range of approval	63
C.3.1	General	63
C.3.2	Manufacturer	63
C.3.3	Material	63
C.3.4	Tube dimensions	63
C.3.5	Expansion factor	63
C.3.6	Joint design	64
C.3.7	Tool	64
C.3.8	PWHT	64
C.4	Expansion Procedure Approval Record (EPAR)	64
C.5	Expansion operator approval	64
C.5.1	General	64
C.5.2	Validity range of expansion operator qualification	65
C.5.3	Qualification tests	65
C.5.4	Examination and testing	65
C.5.5	Period of validity	65
C.5.6	Certification	66
Y.2	List of corrected pages of Issue 2 (2015-07)	67
Y.3	List of corrected pages of Issue 3 (2016-07)	67
Annex ZA (informative) Relationship between this European Standard and the essential requirements of Directive 2014/68/EU aimed to be covered		68
Bibliography		69