Table A.5 — Tubesheets - Tubes to tubesheets *(continued)*

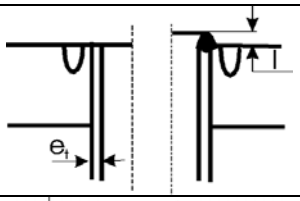
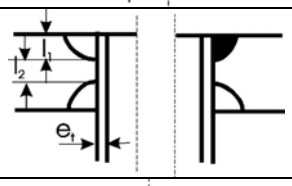
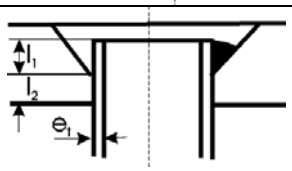
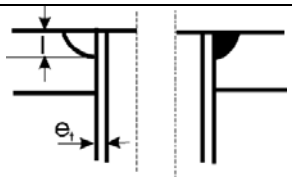
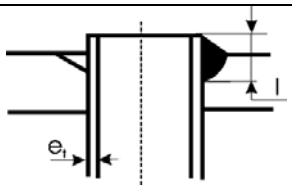
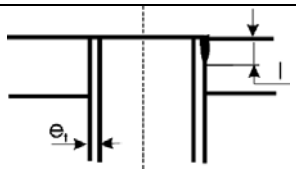
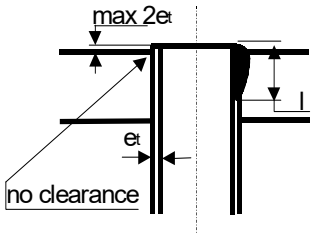
Ref.	Type of joint	Design requirements	Applicable weld testing group	Fatigue class [1]	Lamellar tearing susceptibility [2]	Corrosion [3]	EN 1708-1: 2010
T 8		$e_t \le l \le 1{,}4\, e_t$ NOT ALLOWED FOR DBA-DR AND CREEP DESIGN	1, 2, 3, 4	not allowed	B	S	7.1.5
T 9		$l_1 \ge 1{,}4\, e_t$ $l_2 \le 4\, e_t$ NOT ALLOWED FOR DBA-DR AND CREEP DESIGN	1, 2, 3, 4	40	A	S	-
T 10		$l_2 \le 4\, e_t$ $l_1 \ge e_t + 3\,\text{mm}$ for stay tubes $l_1 \ge e_t + 2\,\text{mm}$ for other tubes NOT ALLOWED FOR DBA-DR AND CREEP DESIGN	1, 2, 3, 4	40	A	S	-
T 11		$l \ge e_t$ NOT ALLOWED FOR DBA-DR AND CREEP DESIGN	1, 2, 3, 4	40	B	S	-
T 12		$l \ge 1{,}4\, e_t$ NOT ALLOWED FOR DBA-DR AND CREEP DESIGN	1, 2, 3, 4	40	B	S	-
T 13		$l \ge e_t$ NOT ALLOWED FOR DBA-DR AND CREEP DESIGN	1, 2, 3, 4	40	B	S	-
T 14		$l \ge 0{,}7\, e_t$	1, 2, 3, 4	40	B	S	-
1), 2), 3) see table A-1							

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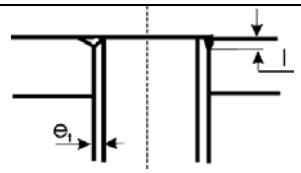
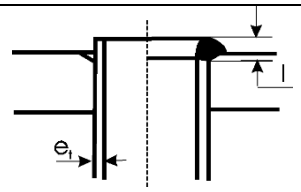
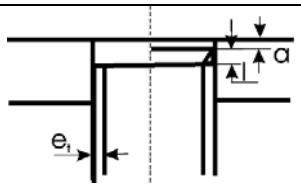
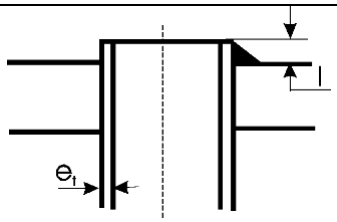
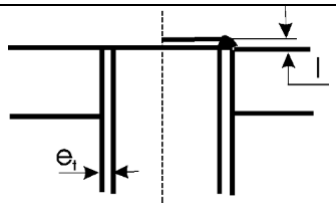
Table A.5 — Tubesheets - Tubes to tubesheets *(concluded)*

Ref.	Type of joint	Design requirements	Applicable weld testing group	Fatigue class [1]	Lamellar tearing susceptibility [2]	Corrosion [3]	EN 1708-1: 2010
T 15		$l \geq e_t$	1, 2, 3, 4	40	B	S	-
T 16		$e_t \leq l \leq 1{,}4\, e_t$	1, 2, 3, 4	40	A	S	7.1.1
T 17		$l \geq 1{,}4\, e_t$ $a \leq e_t$	1, 2, 3, 4	32	B	S	-
T 18		$l \geq 1{,}4\, e_t$	1, 2, 3, 4	40	B	S	7.1.2
T 19		NOT ALLOWED					

1), 2), 3) see Table A-1

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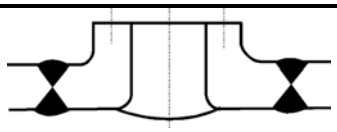
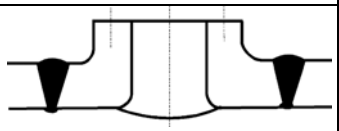
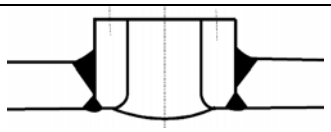
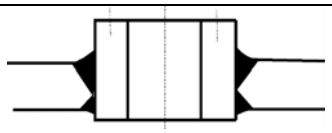
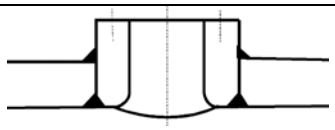
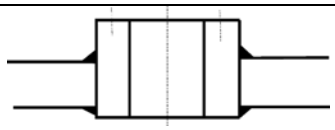
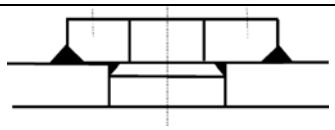
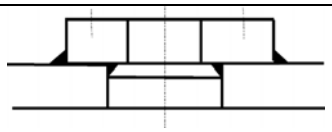
Table A-6 — Socket connections

Ref.	Type of joint	Design requirements	Applicable weld testing group	Fatigue class [1]	Lamellar tearing susceptibility [2]	Corrosion [3]	EN 1708-1: 2010
S 1			1, 2, 3, 4	see Table 18-4 detail n° 7.1	-	N	
S 2		allowed for fatigue only if full penetration can be verified	1, 2, 3, 4	see Table 18-4 detail n° 7.1	-	N	-
S 3			1, 2, 3, 4	see Table 18-4 detail n° 7.1	-	N	-
S 4		NOT ALLOWED FOR DBA-DR AND CREEP DESIGN	3, 4 if $d > 150\,\text{mm}$ 1, 2, 3, 4 if $d \leq 150\,\text{mm}$	see Table 18-4 detail n° 7.1	-	N	-
S 5		$a \geq 0{,}7\,e_{\min}$ for each weld NOT ALLOWED FOR DBA-DR AND CREEP DESIGN	3, 4 if $d > 150\,\text{mm}$ 1, 2, 3, 4 if $d \leq 150\,\text{mm}$	see Table 18-4 detail n° 7.2	-	N	-
S 6		$a \geq 0{,}7\,e_{\min}$ for each weld NOT ALLOWED FOR DBA-DR AND CREEP DESIGN	3, 4 if $d > 150\,\text{mm}$ 1, 2, 3, 4 if $d \leq 150\,\text{mm}$	see Table 18-4 detail n° 7.2	-	N	-
S 7		$a \geq 0{,}7\,e_{\min}$ for each weld NOT ALLOWED FOR DBA-DR AND CREEP DESIGN	3, 4 if $d > 150\,\text{mm}$ 1, 2, 3, 4 if $d \leq 150\,\text{mm}$	see Table 18-4 detail n° 7.4	-	N	-
S 8		$a \geq 0{,}7\,e_{\min}$ for each weld NOT ALLOWED FOR DBA-DR AND CREEP DESIGN	3, 4 if $d > 150\,\text{mm}$ 1, 2, 3, 4 if $d \leq 150\,\text{mm}$	see Table 18-4 detail n° 7.4	-	N	2.1.8

1), 2), 3) see Table A-1

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Table A-7 — Flanges and collars

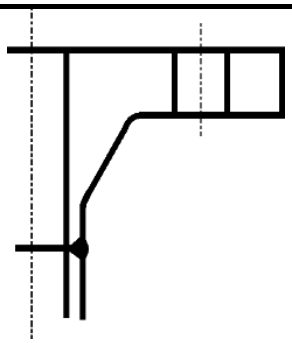
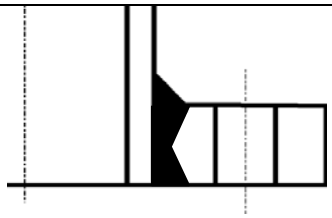
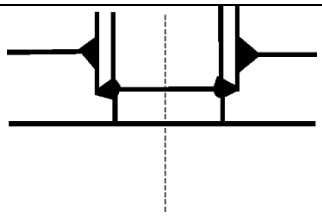
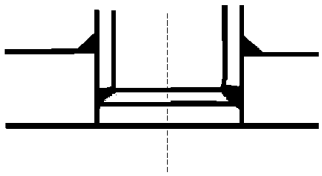
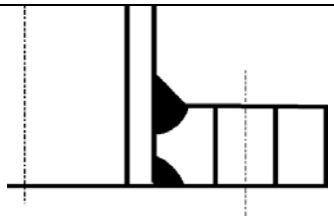
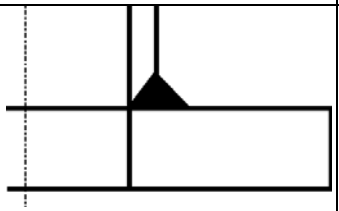
Ref.	Type of joint	Design requirements	Applicable weld testing group	Fatigue class [1]	Lamellar tearing susceptibility [2]	Corrosion [3]	EN 1708-1: 2010
F 1		all allowed circumferential joints can be used	1, 2, 3, 4	see Table 18-4 detail n° 7.1	A	N	5.1.2
F 2		full penetration	1, 2, 3, 4	see Table 18-4 detail n° 7.2	A	N	5.1.1
F 3		$g_1 + g_2 \geq 1{,}4\,e$ NOT ALLOWED FOR DBA-DR AND CREEP DESIGN	3, 4 if $d > 150\,\text{mm}$ 1, 2, 3, 4 if $d \leq 150\,\text{mm}$	see Table 18-4 detail n° 7.4	A B if St1 or St2	N	-
F 4		$g_1 + g_2 \geq 1{,}4\,e$ NOT ALLOWED FOR DBA-DR AND CREEP DESIGN	3, 4 if $d > 150\,\text{mm}$ 1, 2, 3, 4 if $d \leq 150\,\text{mm}$	see Table 18-4 detail n° 7.4	A B if St1 or St2	N	5.1.8
F 5		$g_1 + g_2 \geq 2\,e$ $g_1 - g_2 < 0{,}25\,e$ NOT ALLOWED FOR DBA-DR AND CREEP DESIGN	3, 4 if $d > 150\,\text{mm}$ 1, 2, 3, 4 if $d \leq 150\,\text{mm}$	see Table 18-4 detail n° 7.2	A	N	5.1.1
F 6		full penetration NOT ALLOWED FOR DBA-DR AND CREEP DESIGN	3, 4 if $d > 150\,\text{mm}$ 1, 2, 3, 4 if $d \leq 150\,\text{mm}$	63 50 if inside not visually inspected	A	N	-
1), 2), 3) see Table A-1							

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Table A-7 — Flanges and collars *(concluded)*

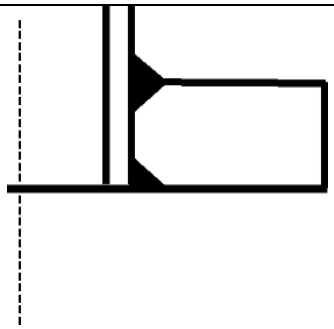
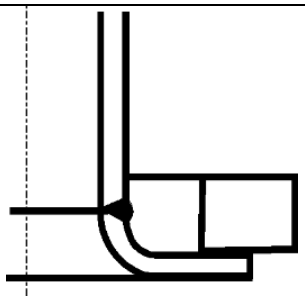
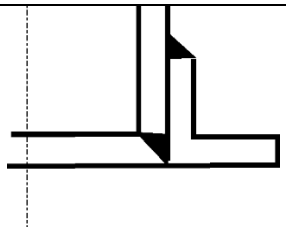
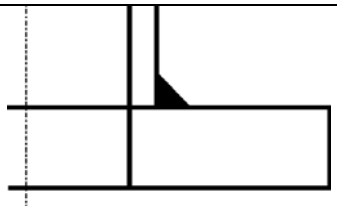
Ref.	Type of joint	Design requirements	Applicable weld testing group	Fatigue class [1]	Lamellar tearing susceptibility [2]	Corrosion [3]	EN 1708-1: 2010
F 7		$g_1 + g_2 \geq 2\,e$ $g_1 - g_2 < 0{,}25\,e$ NOT ALLOWED FOR DBA-DR AND CREEP DESIGN	3, 4 if $d > 150\,\text{mm}$ 1, 2, 3, 4 if $d \leq 150\,\text{mm}$	see Table 18-4 detail n° 7.2	A B if St1 or St2	N	5.1.5
F 8		all allowed circumferential joints can be used NOT ALLOWED FOR DBA-DR AND CREEP DESIGN	1, 2, 3, 4	see F 1	A	N	-
F 9		$a \geq 0{,}7\,e_{\min}$ for each weld NOT ALLOWED FOR DBA-DR AND CREEP DESIGN	3, 4 if $d > 150\,\text{mm}$ 1, 2, 3, 4 if $d \leq 150\,\text{mm}$	32	A B if St1 or St2	N	5.1.4
F 10		NOT ALLOWED					
1), 2), 3) see Table A-1							

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Table A-8 — Nozzles

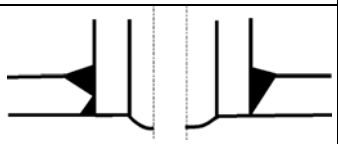
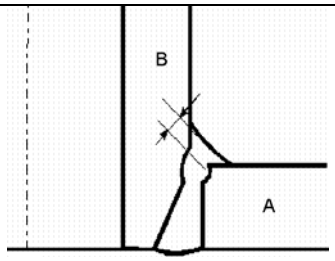
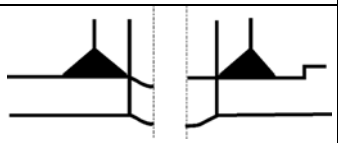
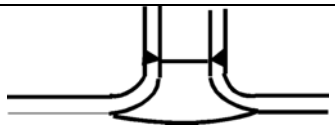
Ref.	Type of joint	Design requirements	Applicable weld testing group	Fatigue class [1]	Lamellar tearing susceptibility [2]	Corrosion [3]	EN 1708-1: 2010
N 1		Full penetration	1, 2, 3, 4	see Table 18-4 detail n° 3.2	B	N	2.2.6 2.3.3
N 2		Full penetration	1, 2, 3, 4	see Table 18-4 detail n° 3.2	B	N	2.2.6
N 3	 **Key** A shell or head B nozzle neck	Full penetration	1, 2, 3, 4	see Table 18-4 detail n° 3.2	B	N	2.2.6
N 4		Full penetration	1, 2, 3, 4	see Table 18-4 detail n° 3.2	B	N	2.1.5
N 5		Full penetration	1, 2, 3, 4	see Table 18-4 detail n° 3.2	B	N	2.1.1
N 6		Full penetration	1, 2, 3, 4	see relevant reference in C	A	N	2.4.1
N 7		$a \geq 0{,}7\, e_{min}$ for each weld $d \leq 600\,\text{mm}$ $d / D \leq 1/3$ NOT ALLOWED FOR DBA-DR AND CREEP DESIGN	3, 4 if $d > 150\,\text{mm}$ 1, 2, 3, 4 if $d \leq 150\,\text{mm}$	see Table 18-4 detail n° 3.2 or 3.3	B	N	2.2.2
1), 2), 3) see Table A-1							

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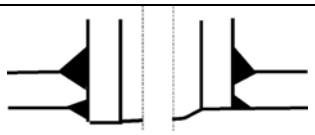
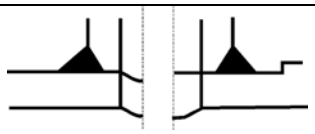
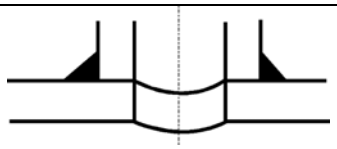
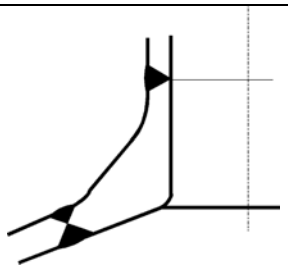
Table A-8 — Nozzles *(concluded)*

Ref.	Type of joint	Design requirements	Applicable weld testing group	Fatigue class [1)]	Lamellar tearing susceptibility [2)]	Corrosion [3)]	EN 1708-1: 2010
N 8		$a \geq 0{,}7\, e_{min}$ for each weld $d \leq 800\,\text{mm}$ $d / D \leq 1/3$ NOT ALLOWED FOR DBA-DR AND CREEP DESIGN	3, 4 if $d > 150\,\text{mm}$ 1, 2, 3, 4 if $d \leq 150\,\text{mm}$	see Table 18-4 detail n° 3.2 or 3.3	B	N	2.2.5
N 9		$a \geq 0{,}7\, e_{min}$ for each weld NOT ALLOWED FOR DBA-DR AND CREEP DESIGN	3, 4	not allowed	B	S	-
N 10		NOT ALLOWED					
N 11		all allowed circumferential joints can be used	1, 2, 3, 4	see relevant reference in C	A	N	

), 2), 3) see Table A-1

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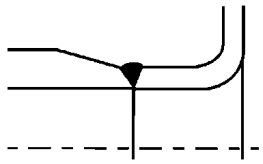
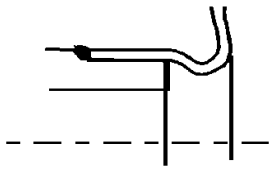
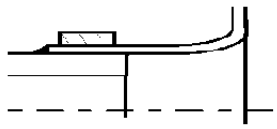
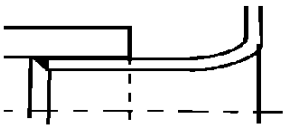
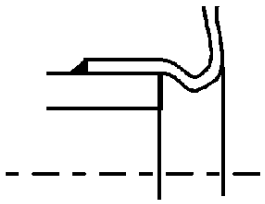
Table A-9 — Circumferential welds in bellows

Ref.	Type of joint	Design requirements	Applicable weld testing group	Fatigue class [1)]	Lamellar tearing susceptibility [2)]	Corrosion [3)]	EN 1708-1: 2010
B 1		Full penetration	1, 2, 3		A	N	-
B 2		$a \geq 0{,}7\, e_b$ NOT ALLOWED FOR DBA-DR AND CREEP DESIGN	1, 2, 3		B	S	-
B 3		$a \geq 0{,}7\, e_b$ NOT ALLOWED FOR DBA-DR AND CREEP DESIGN	1, 2, 3		A	S	-
B 4		$a \geq 0{,}7\, e_b$ NOT ALLOWED FOR DBA-DR AND CREEP DESIGN	1, 2, 3		A	N	-
B 5		$a \geq 0{,}7\, e_b$ NOT ALLOWED FOR DBA-DR AND CREEP DESIGN	1, 2, 3		B	S	-
1), 2), 3) see Table A-1							

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EN 13445-3:2014 (E)
Issue 5 (2018-07)

Annex B
(normative)

Design by Analysis – Direct Route

B.1 Introduction

B.1.1 General

This annex is currently limited to sufficiently ductile materials, like the whole standard, but it is, for components operating in the creep range, also limited to sufficiently creep ductile materials.

NOTE The steels and steel castings listed in EN 13445-2:2014, Table E.2-1 for which, for the relevant temperature range, creep strengths are given in the referred to material standards, are considered to be sufficiently creep ductile".

B.1.2 Purpose

Design-by-analysis (DBA) provides rules for the design of any component under any action. It may be used:

— as an alternative to design-by-formulas (see 5.4.1)

— as a complement to design-by-formulas for:

  — cases not covered by that route;

  — cases involving superposition of environmental actions;

  — cases where the manufacturing tolerances given in EN 13445-4:2014, Clause 5, are not fulfilled, in agreement with the parties concerned.

In the last item, any deviations beyond tolerance limits shall be clearly documented.

B.1.3 Special requirements

Due to the advanced methods applied, until sufficient in-house experience can be demonstrated, the involvement of an independent body, appropriately qualified in the field of DBA, is required in the assessment of the design (calculations) and the potential definition of particular NDT requirements.

B.1.4 Creep design

For components which, under reasonably foreseeable conditions, may operate in the creep range, the lifetime of this creep load case (or the lifetimes for more than one of such load cases) shall be specified (by the user or his representative). For each load case which includes operation in the creep range, the specified time for operation in the creep range shall not be less than 10 000 h. If none is specified, the manufacturer shall assume a reasonable time, but at least 100 000 h.

NOTE Whereas for structures with solely non-creep load cases the load cases can be specified quite independently, the specification of load cases for structures with creep load cases requires careful consideration of the total design life taking into consideration all reasonably foreseeable load cases. Alternative total design lives may be used.

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The (specified or assumed) design life shall be stated in the Technical Documentation.

If calculation temperatures are below the creep range (see 5.1) no creep design checks are required, and B.5.1.3 and B.9 do not apply.

If the minimum of the two values:

a) the product of 1,2 and the creep rupture strength at calculation temperature and for the relevant lifetime,

b) the product of 1,5 and the 1% creep strain strength at calculation temperature and for the relevant lifetime

is larger than the 0,2 % proof strength at calculation temperature, no creep design checks are required, and B.5.1.3 and B.9 do not apply. If the minimum of the two values is not larger than the 0,2 % proof strength at calculation temperature, creep design checks are required, and B.5.1.3 and B.9 apply.

The designations creep rupture strength and 1 % creep strain strength refer to mean values, as specified in the material standard, for which a scatter band of experimental results of ± 20 % is assumed. For larger scatter bands 1,25 times the minimum band values shall be used instead of mean values.

For interpolation and possible extrapolation of strength values, and for the determination of time to creep rupture or 1 % creep strain, the procedures given in Clause 19 shall be used.

B.2 Specific definitions

The following definitions are in addition to those in clause 3.

B.2.1
action
imposed thermo-mechanical influence which causes stress and/or strain in a structure, e. g. an imposed pressure, force, displacement, temperature, see B.6

B.2.2
action type
classification of action based on statistical properties and duration

B.2.3
application rule
generally recognised rule that follows the principles and satisfies their requirements

NOTE Alternative design rules, different from the application rules given in this standard, may be used, provided that it is shown that the alternative rule accords with the relevant principles and is at least equivalent with regard to reliability, serviceability and durability, see B.5.1.

B.2.4
characteristic value/function
a characteristic value of an action is a representative value which takes account of the variation of an action, see B.6.2

NOTE A characteristic function of an action is a representative function (of time) for the action, required for actions for which, in specific design checks, the time-dependence is of importance, e.g. temperature/pressure transients during start-up or shut-down, see B.6.2.3.

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B.2.5
coefficient of variation
measure of statistical dispersion (standard deviation divided by mean value)

B.2.6
combination factor
factor applied to design values of variable actions with stochastic properties if combined with pressure, or if two or more of these actions are included in one load case, see B.8.2.3

B.2.7
design check
investigation of a component's safety under the influence of specified combinations of actions with respect to specified limit states, see B.5.1

B.2.8
design model
structural (physical) model used in the determination of effects of actions

B.2.9
effect
response (e.g. stress, strain, displacement, resultant force or moment, equivalent stress resultant) of a component to a specific action, or combination of actions

B.2.10
limit state
structural condition beyond which the design performance requirements of a component are not satisfied

NOTE Limit states are classified into ultimate and serviceability limit states, see B.4.

B.2.11
load case
a combination of coincident actions. Load cases are classified into normal operating load cases, special load cases and exceptional load cases, see B.5.1

B.2.12
local stress/strain concentration
stress/strain distribution related to very local geometric or material stress/strain raisers or temperature fields, which affect the stress or strain distribution only through a fraction of the thickness

NOTE Local stress/strain distributions are associated solely with localised types of deformation or strain, have no significant non-local effect. Examples are stress concentrations at small fillet radii, small attachments, welds etc.

B.2.13
partial safety factor
factor which is applied to a characteristic value of an action or a material parameter in order to obtain the corresponding design value

NOTE It depends on the design check, the action, material parameter, see B.6.3 and B.7.5.

B.2.14
principle
general or definitive statement, for which there is no alternative, unless specifically stated otherwise, or: Requirement and model, for which no alternative is permitted unless specifically stated, see B.6

B.2.15
structure
combination of all load carrying parts relevant to the component, e.g. the whole vessel, its load carrying attachments, supports and foundations

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