Safety Standards

of the

Nuclear Safety Standards Commission (KTA)

KTA 2502 (2011-11)

Mechanical Design of Fuel Assembly Storage Pools in Nuclear Power Plants with Light Water Reactors

(Mechanische Auslegung von Brennelementlagerbecken in Kernkraftwerken mit Leichtwasserreaktoren)

The previous version of this safety standard was issued in 1990-06

If there is any doubt regarding the information contained in this translation, the German wording shall apply.

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KTA SAFETY STANDARD

November 2011	**Mechanical Design of Fuel Assembly Storage Pools in Nuclear Power Plants with Light Water Reactors**	**KTA 2502**

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PLEASE NOTE: Only the original German version of this safety standard represents the joint resolution of the 50-member Nuclear Safety Standards Commission (Kerntechnischer Ausschuss, KTA). The German version was made public in Bundesanzeiger BAnz No. 11 of January 19, 2012. Copies may be ordered through the Carl Heymanns Verlag KG, Luxemburger Str. 449, 50939 Koeln, Germany (Telefax + 49-221-94373603).

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Comments by the Editor:

Taking into account the meaning and usage of auxiliary verbs in the German language, in this translation the following agreements are effective:

shall	indicates a mandatory requirement,
shall basically	is used in the case of mandatory requirements to which specific exceptions (and only those!) are permitted. It is a requirement of the KTA that these exceptions - other than those in the case of **shall normally** - are specified in the text of the safety standard,
shall normally	indicates a requirement to which exceptions are allowed. However, exceptions used shall be substantiated during the licensing procedure,
should	indicates a recommendation or an example of good practice,
may	indicates an acceptable or permissible method within the scope of this safety standard.

Basic Principles

(1) The safety standards of the Nuclear Safety Standards Commission (KTA) have the task of specifying those safety-related requirements which shall be met with regard to precautions to be taken in accordance with the state of science and technology against damage arising from the construction and operation of the plant (Sec. 7 para. 2 subpara. 3 Atomic Energy Act – AtG) in order to attain the protective goals specified in the Atomic Energy Act and the Radiological Protection Ordinance (StrlSchV) and further detailed in the "Safety Criteria" and in the "Design Basis Accident Guidelines".

(2) Safety standard KTA 3602 specifies the requirements for the layout and design of fuel pools. These design requirements deal with, e.g., capacity, shielding, water quality, criticality safety, leak tightness, possible loadings, and precautionary measures for preventing load crashes. On the basis of these prerequisites, the present safety standard specifies the requirements for the mechanical design of the fuel pool and its internals, i.e., for the mechanical engineering, the structural steel and the reinforced concrete of the fuel pool.

(3) Safety standard KTA 3303 specifies the required fuel pool water temperatures and their respective dependence on the various operating conditions.

(4) The present safety standard specifies the action types and combinations of actions as well as the partial and combination coefficients for the action types and combinations of actions. In addition, it also specifies the requirements regarding verification of the ultimate limit state and of the serviceability limit state, and, supplementing general engineering standards, this safety standard also specifies partial safety factors for the characteristic material property values. Furthermore, requirements regarding permissible materials and the associated materials tests are specified.

(5) General requirements with regard to quality assurance are specified in safety standard KTA 1401.

(6) All plant components classified as structural components are subject to the approved building regulations. This applies to, e.g., reinforced concrete, reinforcing steel, headed studs, anchor plates.

1 Scope

This safety standard applies to the mechanical design of fuel pools and their internals in nuclear power plants with light water reactors.

N o t e :

This standard can be applied analogously to other pools with comparable safety requirements.

2 Definitions

N o t e :

The terms permanent, variable and accidental action, action types, combinations of actions, design situations, partial safety factor, ultimate limit state and serviceability limit state are used herein as defined in DIN EN 1990.

(1) Fuel pool water temperature

The fuel pool water temperature as specified in safety standard KTA 3303 is the mixture temperature existing at a sufficient depth down in the fuel pool close to wall.

N o t e :

Experience shows that only minor differences exist between the temperatures measured in the fuel pool and in the extraction line of the fuel pool cooling system; therefore, the design and controls can be based on the measurement of the fuel pool water temperature.

(2) Requirement category

Requirements specified for safety relevant parts will be different depending on the action types taking the following aspects into consideration:

a) probability of occurrence during the service life,

b) repair possibilities, and

c) limiting the extent of the damage such that, e.g., the serviceability of the respective parts or the stability and functionality of the plant components are maintained.

Depending on these aspects, the parts will be assigned to the different requirement categories A1, A2 or A3 (cf. Section 4.1).

3 Types of Actions

3.1 Permanent Actions (G)

The permanent actions (G) to be considered for the parts or components of the fuel pool are listed in **Table 3-1**.

Nomenclature	Type of Action
a	Dead loads
b	Load from weight of water (static pressure of the coolant)
c	Loads from fuel pool internals (e.g. racks, refueling slot gates, inspection equipment)
d	Temperature actions: cf. **Table 3-4**
e	Loads from the connecting pipes
f	Loads from bordering and supported components
g	Restricted or restrained imposed deformations or movements (e.g., creepage and shrinkage of concrete)

Table 3-1 Permanent actions

3.2 Variable actions (Q)

The variable actions (Q) to be considered for the parts or components of the fuel pool are listed in **Table 3-2**.

3.3 Accidental actions (A)

(1) The accidental actions (A) to be considered for the parts or components of the fuel pool are caused by those plant internal design basis accidents and by the external events that must be considered for the overall plant at the site of the power plant.

(2) Examples for the accidental actions are listed in **Table 3-3**.

N o t e :

The load drop of heavy objects into the fuel pool or onto components of the fuel pool does not have to be assumed in view of the safety standards KTA 3602, KTA 3902 and KTA 3905.

Nomen-clature	Type of Action
d	Temperature actions: cf. **Table 3-4**
e	Loads from the connecting pipes
f	Loads from bordering and supported components (e.g., refueling equipment)
h	Loads from setdown events (jolts from operational procedures)
i	Loads from the stored materials (e.g., fuel assemblies, control rods)
k	Loads from transportation or storage containers (e.g., fuel element casks) including lifting accessories, load-bearing equipment and hoisting gear
l	Loads caused by movements of the slot gates (e.g., friction forces)

Table 3-2 Variable actions

Nomen-clature	Type of Action
d	Thermal actions: cf. **Table 3-4**
e	Loads from the connecting pipes
h	Loads from setdown events (jolts from unplanned procedures)
m	Loads from external events (e.g., design basis earthquake in accordance with safety standard KTA 2201.1) including sloshing water
n	Loads from plant internal design basis accidents (e.g., jet impingement forces)

Table 3-3 Accidental actions

Action type [3]	Temperature of the Fuel Pool Water [1]	Temperature of the Bordering Rooms [2]
Permanent actions (G)	T_1	T_{R1}
Variable actions (Q)	T_2	T_{R1}
Accidental actions (A)	T_3	T_{R1}
	T_1	T_{R2}

[1] Temperatures T_1, T_2 and T_3 are specified in safety standard KTA 3303.

[2] T_{R1} is the temperature of the operating condition; T_{R2} is the increased temperature due to design basis accidents.

[3] For further explanations, cf. Section 6.2.

Table 3-4: Thermal actions

4 Requirement Categories and Combinations of Actions

4.1 Requirement Categories

(1) Parts and components shall be subject to different requirements in accordance with the respective combinations of actions specified under Section 4.2. For the design, the different combinations of actions shall be assigned with one of the Requirement categories A1, A2 or A3 specified below. The corresponding load-bearing capacities for the parts and components shall be determined as specified under Section 5.3 for the respective Requirement category.

(2) Requirement Category A1:

Combinations of operational actions that result from the permanent and temporary design situations in accordance with DIN EN 1990 shall be assigned to Requirement Category A1. Complete functionality, the resistance to repeated loading, and a continuous reusability shall remain ensured after occurrence of these combinations.

(3) Requirement Category A2:

Combinations of variable and accidental actions that must be assumed to occur repeatedly in the course of service life shall be assigned to Requirement Category A2. Complete functionality shall be remain ensured after occurrence of these combinations.

(4) Requirement Category A3:

Combinations of accidental actions with a low probability of occurrence (smaller than or equal to 10^{-4} per year) that must be assumed to occur once in the course of service life shall be assigned to Requirement Category A3. Major plastic deformations (combined with major crack formations in the case of steel-reinforced concrete) are permissible, provided, this is not in contradiction to safety related issues.

4.2 Combinations of Actions

4.2.1 Combinations of actions for parts made of steel or for other components

(1) The design of the parts made of steel or of other components shall be based at least on the combinations of actions specified in **Table 4-1**. Any combinations of actions, parts or components not listed in **Table 4-1** shall be dealt with analogously. A mutual combination of the various accidental actions (A) specified under Section 3.3 is not required.

(2) Loads resulting from deformations of the reinforced concrete structure (e.g., creepage and shrinkage) that act on the fuel pool liner and its anchorings shall be taken into account.

(3) Dependent on the technical design of the substructure for the liner sheet, of the wall frame work, bottom frame work, slot gate frame and transport cask setdown area, the water load shall, additionally, be taken into account for all combinations of actions.

(4) The thermal actions listed in **Table 3-4** shall be taken into account in the case of parts that may be subject to restraint forces from temperature changes.

4.2.2 Combinations of actions for parts made of concrete and reinforced concrete

(1) For the design of the reinforced concrete structure, the actions specified under Section 3 shall be combined in accordance with the rules specified under Section 5.2.

(2) Only technically feasible combinations of actions shall be taken into account. Concerned are loads from reactions of parts made of steel or other components due to the combinations of actions listed in **Table 4-1**. A mutual combination of the various accidental actions (A) specified under Section 3.3 is not required.

Parts or Components		Requirement Category		
		A1 [5]	A2 [5]	A3 [5]
1	Liner sheet	d	d [6]	d [6]
2	Bottom frame work	c + i + h at T_1	c + i at T_2 c + i + h at T_1	c + i at T_3 c + i + m at T_1
3	Anchor plates, mountings on anchor plates (weld attachments and consoles), wall frame work	c + f + h at T_1	c + f at T_2 c + f + h at T_1	c + f at T_3 c + f + m at T_1
4	Slot gate	a + b + h at T_1	a + b at T_2 a + b + h at T_1 a + b + l at T_1	a + b at T_3 a + b + m at T_1
5	Slot gate frame	Actions from reactions to the combinations of actions of row 4		
6	Steel pipe penetration	e [1]	e [1]	e [1]
7	Fuel assembly rack	a + i + h at T_1	a + i at T_2 a + i + h at T_1	a + i at T_3 a + i + m at T_1
8	Fuel assembly rack fixation	Actions from reactions to the combinations of actions of row 7		
9	Other racks and internals [2] that are not safety related	a + i + h at T_1	a + i at T_2 a + i + h at T_1	a + i at T_3 a + i + m at T_1
10	Mobile shielding	a	-	a + m at T_1 [3]
11	Observation window [4]	a + b at T_1	a + b at T_2	a + b at T_3 a + b + m at T_1
12	Hydraulic compensator	a + b + relative displacements at T_1	a + b + relative displacements at T_2	a + b + relative displacements at T_3 a + b + m [3] + relative displacements at T_1

1) Actions result from the analysis of the connecting pipe systems.

2) Verification for A1 is sufficient, provided, sequential damages have no safety related significance.

3) Provided, this is required on account of risk assessments.

4) Glass window pane in accordance with the special agreement with, and specification of, the manufacturer.

5) Cf. Section 3 regarding nomenclatures a through m, as well as T_1, T_2 and T_3.

6) To be verified for the number of load cycles, cf. Section 6.1.2 para. 4.

Table 4-1: Combinations of actions for selected parts made of steel or for components

5 Verifications

5.1 General Requirements

(1) Verifications may be performed either analytically or experimentally or by combining analysis and experiment. In this context, the methods developed for analyzing bending and the static equilibrium of bars and rods as well as the analytical methods described in Appendix B of safety standard KTA 3201.2 (e.g., finite element methods) may be used or other to be specified methods.

(2) The mechanical design of the parts and components shall basically follow the safety concept specified in accordance with DIN EN 1990. Any deviations from this safety concept shall be substantiated. It shall be verified that the design value of the load does not exceed the design-basis value, cf. **Figure 5-1**. The verification shall be performed taking the correlation of combinations of actions and requirement categories as specified in Section 4.1 for the parts and components into account.

(3) The partial safety factors, γ_F, and the combination coefficients, ψ, to be applied in determining the combinations of actions for the ultimate limit state and the serviceability limit state, as well as the partial safety factors, γ_M, to be applied in determining the load bearing capacities are specified in Sections 5.2 and 5.3.

(4) The verifications required with respect to the limit states of parts made of steel or other steel components shall be performed in accordance with Parts 1-1, 1-3 through 1-10 and 1-12 of DIN EN 1993. In addition to DIN EN 1993-1-4, the requirements specified in DIBt General Construction Approval Z-30.3-6 shall be taken into account. The parts made of reinforced concrete shall be dimensioned in accordance with DIN EN 1992-1-1 under special consideration of the dimensioning specifics presented in DIN 25449. All deviations specified in the present safety standard with regard to the technical standards cited above shall be taken into account.

(5) In individual cases and under certain prerequisites, it is permissible to also perform the stress analyses in accordance with other, then to be specified verification procedures (e.g., concept of stress limitation).

5.2 Limit States

5.2.1 Ultimate limit state (ULS)

The appropriate combination rules for actions of the design situations concerning the ultimate limit state (ULS) are specified in DIN EN 1990. Accordingly, it is required to distinguish between permanent, variable and accidental design situations and those design situations on account of earthquakes.

5.2.2 Serviceability limit state (SLS)

The appropriate combination rules for actions of the design situations concerning the serviceability limit state (SLS) are specified in DIN EN 1990. Accordingly, it is required to distinguish between seldom (characteristic), frequent and quasi permanent design situations.

5.2.3 Partial and combination coefficients

Unless otherwise specified in **Table 5-1**, the partial safety factors for permanent actions, γ_G, for variable actions, γ_Q, and for accidental actions, γ_A, shall be chosen in accordance with Appendix A.1 of DIN EN 1990. A partial safety factor of 1.00 shall be applied to the combination rules for the serviceability limit state.

5.3 Load-bearing Capacities

5.3.1 Design-basis values

The design-basis values of the load-bearing capacities shall be calculated as the quotient of the characteristic values of the load-bearing capacities of the parts or other components and the material dependent partial safety factors specified under Section 5.3.2.

5.3.2 Partial safety factors

The partial safety factors, γ_M, for determining the load-bearing capacity at the ultimate limit state are dependent on the design situation (permanent and variable, and accidental including earthquake), on the structural materials as well as on the applicable requirement categories specified under Section 4.1. Regarding parts made of concrete and reinforced concrete, the required partial safety factors are listed in **Table 5-2**. Regarding parts made of steel and other steel components, the partial safety factors are independent of the requirement category and shall be chosen depending on the respective material in accordance with DIN EN 1993-1 or DIN EN 1993-1-4, respectively. Partial safety factors for other materials shall be chosen in accordance with the approved engineering standards.

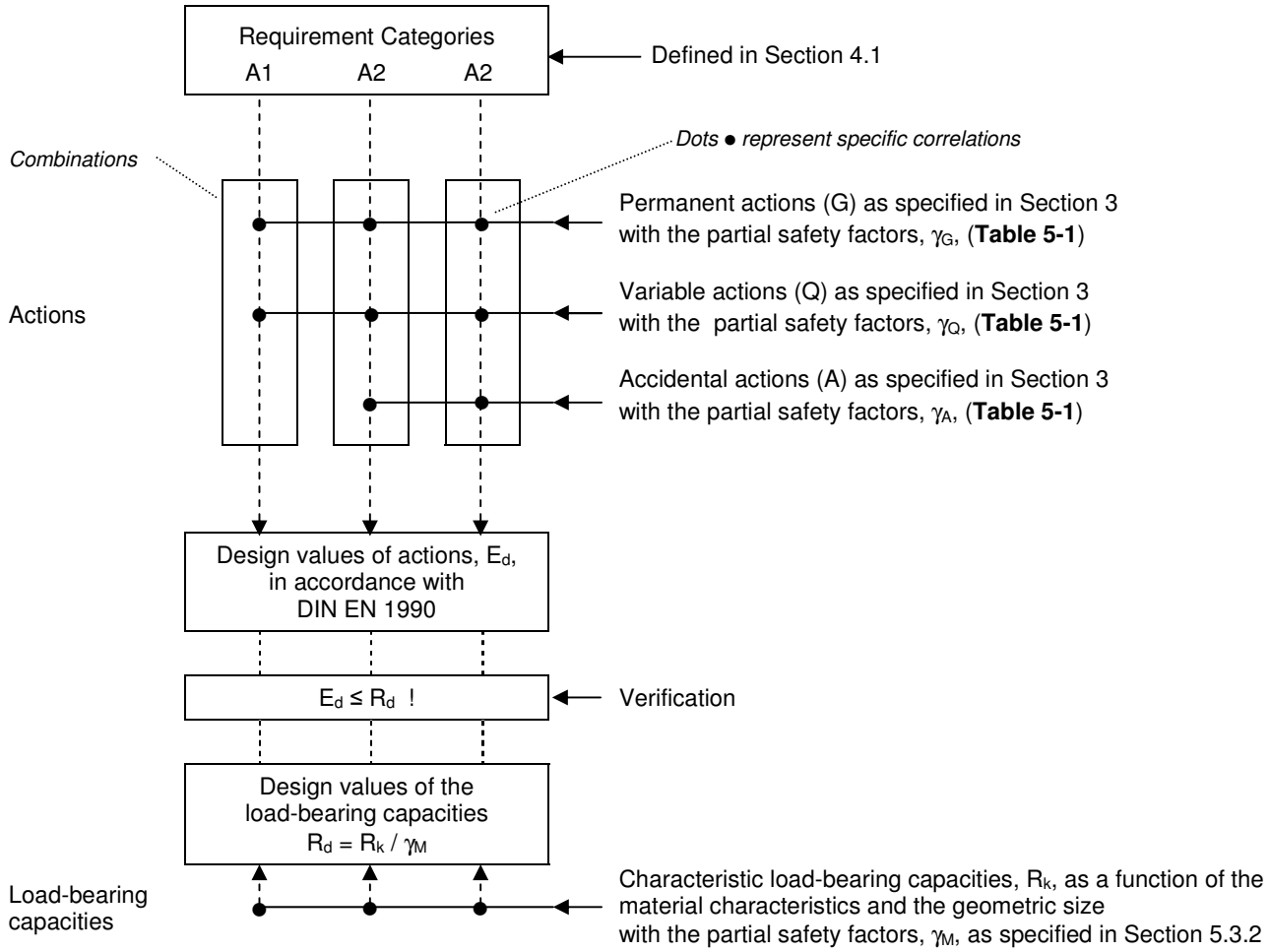

Figure 5-1: Procedural diagram for verifying the ultimate limit state (ULS)

Actions		***Partial Safety Factor*** $\gamma_G, \gamma_Q, \gamma_A$	***Combination Coefficient*** ψ_0	ψ_1	ψ_2
Permanent actions (G)	Dead weight, cf. **Table 3-1**, a	1.35 [1)]	–	–	–
	Water weight, cf. **Table 3-1**, b	1.20 [1), 4)]			
	Other loads, cf. **Table 3-1**, c, e, f	1.35 [1)]			
	Restrictions, cf. **Table 3-1**, g	1.00			
	Thermal actions, cf. **Table 3-4**	1.35 [1), 2)]			
Variable actions (Q)	Quasi stationary pay load, cf. **Table 3-2**, i, k	1.35	1.0	1.0	1.0
	Variable pay load, cf. **Table 3-2**, e, h, f, l	1.50 [3)]	0.9	0.8	0.8
	Thermal actions, cf. **Table 3-4**	1.50 [2)]	0.6	0.5	0.0
Accidental actions (A)	Thermal actions, external events, actions from plant-internal design-basis accidents, cf. **Table 3-3**	1.00	–	–	–

[1)] 1.00 in case of favorable actions.

[2)] The temperature-induced constraint loading may be determined by non-linear analyses. In case a linear analysis is performed and a reduction of the stiffness of the load support structure is possible (e.g., due to formation of cracks or to relaxation), then a value of 1.00 may be used.

[3)] 1.35 if the load parameter has the quality of a dead weight.

[4)] Because the load parameter can highly exactly be determined, it is up to the partial safety factor to account for any inaccuracies in the analyses and system assumptions.

Table 5-1: Reference values for the partial and combination coefficients for the ultimate limit state (ULS)

		Requirement Category		
		A1	***A2***	***A3***
Partial safety factors	Concrete, γ_c	1.50	1.30	1.00
	Reinforced concrete, γ_s	1.15	1.00	1.00
Non-linear analyses	System resistance, γ_R	1.30	1.10	1.00
	Compressive strength of concrete, f_{cR} [1)]	$0.85 \cdot \alpha \cdot f_{ck}$	$0.85 \cdot \alpha \cdot f_{ck}$	$1.0 \cdot \alpha \cdot f_{ck}$
	Yield strength of reinforcing steel, f_{yR} [2)]	$1.1 \cdot f_{yk}$	$1.1 \cdot f_{yk}$	$1.0 \cdot f_{yk}$

[1)] Reduction factor, α, in accordance with DIN EN 1992-1-1

[2)] Tensile strength of reinforcing steel $f_{tR} = 1.08 \times f_{yR}$

Table 5-2: Partial safety factors for determining the load bearing capacity of parts made of concrete and reinforced concrete at the ultimate limit state (normal concrete up to C50/60, and high ductility reinforcing steel)

6 Verification Procedures

6.1 Procedure for Analyzing the Load Support Structure, and Verification

6.1.1 Parts made of concrete and reinforced concrete

(1) The following procedures may be utilized in determining the deformation and stress condition for verifying the ultimate limit state (ULS) and the serviceability limit state (SLS):

a) Linear-elastic analysis,

b) linear-elastic analysis with a limited load redistribution (only in the case of ULS),

c) analytical procedures according to the theory of plasticity (only in the case of ULS), and

d) non-linear analytical procedures.

The basic course to be followed for these procedures shall be in accordance with DIN EN 1992-1-1.

(2) In view of the verification of the integrity of the fuel pool liner and in view of the verification that the dimensional accuracy requirements for the plant-engineering components are maintained, the analytical procedures, aside from providing the basic stress evaluation, shall also make it possible to evaluate the deformation of the fuel pool structure. The interaction between the concrete structure and the plant-engineering components shall be taken into consideration in those cases where this interaction has a noticeable effect on the stress and deformation conditions.

(3) The time and temperature dependent characteristics of concrete shall be taken into account. The time dependent deformations of concrete (creepage and shrinkage) shall be determined in accordance with DIN EN 1992-1-1.

(4) The parts made of concrete and reinforced concrete shall be dimensioned in accordance with DIN EN 1992-1-1 under special consideration of the dimensioning specifics presented in DIN 25449.

(5) Regarding the structural material concrete, deviations from the characteristics relevant to dimensioning as specified in accordance with DIN EN 1992-1-1 are permissible, provided, these are well substantiated and verified. This concerns, in particular, the subsequent hardening of many-years old concrete structures as well as the strength increase of concrete in the case of multi-axial stress states.

6.1.2 Structures from steel

(1) In accordance with DIN EN 1993-1-1, the following procedures may be utilized in determining the deformation and stress condition for verifying the ultimate limit state (ULS) and the serviceability limit state (SLS):

a) Elastic - Elastic
(stress resultants by the theory of elasticity - stress resistance by the theory of elasticity)

b) Elastic - Plastic
(stress resultants by the theory of elasticity - stress resistance by the theory of plasticity)

c) Plastic - Plastic
(stress resultants by the plastic hinge theory - stress resistance by the theory of plasticity)

(2) Those verification procedures listed above that pertain to the theory of plasticity are based on the plastic hinge theory. A verification on the basis of nonlinear analytical methods that go beyond the simplified methods of the plastic hinge theory and take into account the more realistic elastic/plastic behavior of the materials is also permissible.

(3) When determining the loads for the fuel pool liner and its anchoring elements, the forced deformations caused by the concrete support structure shall be taken into account in addition to the directly effective actions (thermal actions).

(4) In the case of repetitive loads, in particular due to constrained thermal expansion, the functional safety shall be verified by a fatigue analysis taking the weld seams into account. Provided, no differing requirements are specified, the fatigue analysis shall be based on the following minimum number of stress cycles:

a) Requirement Category A2: 500

b) Requirement Category A3: 10

N o t e :

The fatigue analysis can be performed based on specifications in accordance with DIN EN 1993-1-9 and DIN EN 1993-1-7.

(5) If deformations of the concrete are restrained upon parts made of steel, the strain expansions shall protect against the resulting loads. The limit strains shall be specified for each individual case.

N o t e :

Verification of the protecting strain expansion can also be applied to a verification of leak-tightness of the liner sheets.

(6) Influence from friction forces shall be evaluated.

(7) The contact Hertzian stress shall be verified in the case of Requirement Category A1. Provided, no differing requirements are specified for the particular case of application and that no verification of a higher accuracy is performed, then the characteristic parameters for calculating the contact Hertzian stress may be chosen as listed in **Table 6-1**. The partial safety factor, γ_M, is specified as $\gamma_M = 1.1$.

Material	***Parameter $\sigma_{H,k}$ for Requirement Category A1***
1.4541 1.4550	2.7 $f_{y,k}$
1.4313 1.4057	1.5 $f_{y,k}$

Table 6-1: Characteristic parameter, $\sigma_{H,k}$, for the calculation of the contact Hertzian stress

(8) In the case of other materials than the ones listed in **Table 6-1**, the permissible contact Hertzian stress shall be determined in analogy to **Table 6-1**.

6.2 Accounting for Thermal Actions

(1) The temperature boundary conditions specified in **Table 3-4** will cause permanent and variable temperature distributions in the fuel pool structure. The stress related temperature differences with respect to the stress-free original condition that are caused by these stress-effective temperature differences shall be taken into account in the analytical model employed. The calculation of temperatures shall take the temperature dependent characteristics of the materials into account.

(2) In the case of permanently effective temperatures as specified in **Table 3-4**, taking account of the thermal actions may be limited to a permanent temperature distribution in the fuel pool structure.

(3) The variable and accidental thermal actions specified in **Table 3-4** will cause unsteady temperature distributions that are dependent on the chronological sequence of the surface temperatures influencing the fuel pool. The unfavorable restraint stress conditions resulting from these temperature distributions shall be taken into account when dimensioning the parts of the fuel pool. The thermal stresses may be determined under consideration of the stiffness reduction due to

the formation of cracks and to the relaxation of the concrete (cf. footnote 2 of **Table 5-1**).

7 Materials and Materials Testing

7.1 Materials

7.1.1 General requirements

(1) All materials specified in this safety standard may be applied. This statement does not affect any possibly required approval under building legislation.

(2) Other materials than the ones specified may be applied, provided, their suitability is verified.

Note:

The suitability can be verified, e.g., by operating experience, by comparable applications (fluid media, temperature), or by laboratory experiments.

7.1.2 Metallic materials

(1) Metallic materials permitted for load-bearing or leak-tight component parts are listed – correlated with the respective range of application – in **Tables 7.1-1** through **7.1-4**. Corrosion resistant materials shall be employed for those component parts contacting fluid media.

Note:

It shall be ensured by suitable measures within the framework of construction testing that component parts contacting fluid media stay free from foreign ferrites, e.g., by using demineralized water for the intermediate storage of small parts like washers and splints.

(2) Weld consumables and additives shall be tested in accordance with DIN EN 14532-1 and DIN 14532-2 for their suitability with regard to the respective base metals and the welding processes.

7.1.3 Concrete and reinforced concrete

(1) In addition to the technical building standards approved under building legislation for the manufacture of concrete and reinforcing steel and for the application of accessory building materials, all application-related boundary conditions shall be observed (e.g., preventing corrosion damage to the fuel pool liner).

(2) Materials that could attack the fuel pool liner shall be avoided on the fuel pool side of the formwork.

7.1.4 Synthetic materials

The following parameters shall be specified for synthetic materials dependent on their application:

a) type of material,

b) hardness of the material,

c) radiation resistance,

d) resistance against ambient media,

e) heat resistance, and

f) permissible contaminations (e.g., chlorides, fluorides).

7.2 Material Testing and Verification

(1) Requirements of the approved engineering standards shall be applied.

(2) The requirements, type and extent of the necessary material tests, the identification marking as well as the verification proofs in accordance with DIN EN 10204 are specified in the Material Test Sheets of Appendix A for load-bearing parts and parts ensuring leak tightness.

(3) Ferritic steel sheets, wide flats and profiles with a thickness equal to or larger than 15 mm that are stressed by weld connections in the direction perpendicular to the major surface shall be delivered with improved properties in accordance with DIN EN 10164.

(4) In the case of synthetic materials, the manufacturer shall confirm that the characteristics specified under Section 7.1.4 are ensured.

(5) It shall be verified that the manufacturing plant of the product forms has suitable technical facilities and trained personnel for the fabrication as well as testing of the products at its disposal. The manufacturer shall have installed a certified quality management system (e.g., in accordance with DIN EN ISO 9001).

(6) In case of concrete and reinforced concrete, the verifications regarding conformance and usability shall be performed in accordance with the requirements of the technical building standards approved under building legislation as well as of the DIBt Construction Products List A Part 1.

MTS	*Product Forms*	*Permissible Materials*	*Range of Application*
1.1a	Sheets, s ≤ 160 mm, and strips, s ≤ 8 mm	1.4306 1.4401 1.4436 1.4541 1.4550 1.4571	Anchor plates Frame work of the fuel pools Weld attachments Racks and other internals
1.1b	Forgings and forged bars	1.4306 1.4401 1.4436 1.4541 1.4550 1.4571	
1.1c	Rolled bars	1.4306 1.4401 1.4436 1.4541 1.4550 1.4571	
1.1d	Profiles	1.4306 1.4401 1.4436 1.4541 1.4550 1.4571	
1.2	Forgings and forged bars D ≤ 400 mm	1.4313	
1.3	Forgings and bars	1.4021 + QT700 or + QT800 1.4057 + QT800 1.4122 + QT750	
1.4	Sheets and strips, s ≤ 6 mm	1.4541 1.4571	Liner sheets
1.5	Headed studs SD3	1.4301 1.4303	Headed studs for arc stud welding
1.7	Sheets	Stainless austenitic steel with boron additives	Absorber channels for fuel storage racks

Table 7.1-1: Stainless steels; sheets, strips, profiles, forgings, bars and studs

MTS	*Product Forms*	*Permissible Materials*	*Range of Application*
2.1a	Seamless or welded steel pipes p ≤ 0.5 bar, p × DN ≤ 1000 or ≤ DN32	1.4541 1.4550 1.4571	Pipe penetrations of the cooling or cleaning circuits and other steel pipe penetrations Steel structures inside the fuel pools, e.g., racks, supports
2.1b	Seamless or welded fittings (pipe bends, reducers, T-junctions, caps) p ≤ 0.5 bar, p × DN ≤ 1000 or ≤ DN32	1.4541 1.4550 1.4571	Constructions inside the fuel pools, e.g., sprinkler (or sparger) pipes, flow baffles Leakage pipes

Table 7.1-2: Stainless steels; pipes and fittings

MTS	*Product Forms*	*Permissible Materials*	*Range of Application*
3.1	Bolts and nuts of strength category 50, 70 and 80	Austenitic steel types A2, A3, A4 and A5 and martensitic steel type C3 in accordance with DIN EN ISO 3506-1 for bolts, and DIN EN ISO 3506-2 for nuts	Bolt connections in contact with fluid media
3.2	Bolts of strength category 5.6 and 8.8 Nuts of strength category 5 und 8	Ferritic steel types in accordance with DIN EN ISO 898-1 for bolts and DIN EN 20898-2 for nuts	Bolt connections not in contact with fluid media

Table 7.1-3: Bolts and nuts

MTS	*Product Forms*	*Permissible Materials*	*Range of Application*
4.1a	Sheets, strips, wide flats, profiles and rolled bars	S235JR (1.0038) S235J2 (1.0117) S355J2 (1.0577)	Steel and mechanical structures not in contact with fluid medium
4.1b	Sheets	P265GH (1.0425)	
4.1c	Hot-worked profiles (seamless or welded)	S235JRH (1.0039) S355J2H (1.0576)	
4.2	Headed studs SD1	S235J2 + C450	Headed studs for arc stud welding

Table 7.1-4: Structural steels; sheets, strips, wide flats, profiles, bars and headed studs

Appendix A
Material Test Sheets

Material Test Sheet	**MTS 1.1a**	
Product forms:	Sheets s ≤ 160 mm [1] and strips s ≤ 8 mm	**Certification:** Test certification in accordance with DIN EN 10204
Materials:	1.4306, 1.4401 [2], 1.4436 [2], 1.4541, 1.4550, 1.4571	
Requirements:	in accordance with DIN EN 10028-7	
Test specimen removal and extent of tests:	in accordance with DIN EN 10028-1 and DIN EN 10028-7 and the specifications of this material test sheet	
Tests: 1. Chemical composition Chemical analysis of the melt including declaration of melting process 2. Verification of the heat treatment condition 3. Tensile test at room temperature 4. Verification of the resistance against intergranular corrosion in accordance with Procedure A of DIN EN ISO 3651-2; one test specimen per melt and heat treatment lot 5. Visual examination and dimensional check of each part Requirements depend on the individual application 6. Material verification test by a suitable procedure on each part		3.1
Identification marking: in accordance with DIN EN 10028-1		

[1] The mechanical values specified in accordance with DIN EN 10028-7 for hot-rolled sheets with s ≤ 75 mm shall also apply to sheets in the thickness range 75 mm < s ≤ 160 mm.

[2] In case of a contact with fluid media, only s ≤ 6 mm is permissible.

Material Test Sheet	**MTS 1.1b**	
Product forms:	Forgings and forged bars	**Certification:** Test certification in accordance with DIN EN 10204
Materials:	1.4306, 1.4401 [1], 1.4436 [2], 1.4541, 1.4550, 1.4571	
Requirements:	in accordance with DIN EN 10222-5 or DIN EN 10250-4	
Test specimen removal and extent of tests:	in accordance with DIN EN 10222-1 or DIN EN 10250-1 and with specifications of this material test sheet	
Tests: 1. Chemical composition Chemical analysis of the melt including declaration of melting process 2. Verification of the heat treatment condition 3. Tensile test at room temperature 4. Verification of the resistance against intergranular corrosion in accordance with Procedure A of DIN EN ISO 3651-2; one test specimen per melt and heat treatment lot 5. Visual examination and dimensional check of each part Requirements depend on the individual application 6. Material verification test by a suitable procedure on each part		3.1
Identification marking: in accordance with DIN EN 10222-1 or DIN EN 10250-1		

[1] In case of a contact with fluid media, only thicknesses or diameters ≤ 40 mm are permissible.

[2] In case of a contact with fluid media and thicknesses or diameters > 40 mm, no welding or cold forming procedures are permissible.

Material Test Sheet	**MTS 1.1c**	
Product forms:	Rolled bars	**Certification:** Test certification in accordance with DIN EN 10204
Materials:	1.4306, 1.4401 [1)], 1.4436 [2)], 1.4541, 1.4550, 1.4571	
Requirements:	in accordance with DIN EN 10272	
Test specimen removal and extent of tests:	in accordance with DIN EN 10272 and the specifications of this material test sheet	
Tests: 1. Chemical composition Chemical analysis of the melt including declaration of melting process 2. Verification of the heat treatment condition 3. Tensile test at room temperature 4. Verification of the resistance against intergranular corrosion in accordance with Procedure A of DIN EN ISO 3651-2; one test specimen per melt and heat treatment lot 5. Visual examination and dimensional check of each rod Requirements depend on the individual application 6. Material verification test by a suitable procedure on each bar		3.1
Identification marking: in accordance with DIN EN 10272		

[1)] In case of a contact with fluid media, only thicknesses or diameters ≤ 40 mm are permissible.

[2)] In case of a contact with fluid media and thicknesses or diameters > 40 mm, no welding or cold forming procedures are permissible.

Material Test Sheet	**MTS 1.1d**	
Product forms:	Profiles	**Certification:** Test certification in accordance with DIN EN 10204
Materials:	1.4306, 1.4401 [1) 2)], 1.4436 [1) 2)], 1.4541, 1.4550, 1.4571	
Requirements:	in accordance with DIN EN 10088-3	
Test specimen removal and extent of tests:	in accordance with DIN EN 10088-3 and the specifications of this material test sheet	
Tests: 1. Chemical composition Chemical analysis of the melt including declaration of melting process 2. Verification of the heat treatment condition 3. Tensile test at room temperature 4. Verification of the resistance against intergranular corrosion in accordance with Procedure A of DIN EN ISO 3651-2; one test specimen per melt and heat treatment lot 5. Visual examination and dimensional check of each profile Requirements depend on the individual application; Surface condition: Quality Grade D3 in accordance with DIN EN 10163-3 6. Material verification test by a suitable procedure on each profile		3.1
Identification marking: in accordance with DIN EN 10088-3		

[1)] In case of a contact with fluid media, the resistance against inter-granular corrosion in the delivery condition shall be ensured.

[2)] In case of a contact with fluid media, no welding or cold forming procedures are permissible.

Material Test Sheet	**MTS 1.2**	
Product forms:	Forgings and forged bars, D ≤ 400 mm	**Certification:** Test certification in accordance with DIN EN 10204
Materials:	1.4313	
Requirements:	in accordance with VdTÜV-WB 395/3, Secs. 3, 4, 5, 6, 8, 9 and 11	
Test specimen removal and extent of tests:	in accordance with VdTÜV-WB 395/3, Sec. 10 and the specifications of this material test sheet	
Tests: 1. Chemical composition Chemical analysis of the melt including declaration of melting process 2. Verification of the heat treatment condition documenting the temperatures, holding and cooling-down times 3. Tensile test at room temperature in accordance with DIN EN ISO 6892-1 4. Notch bend test at room temperature in accordance with DIN EN 10045-1 5. Hardness test on each part when testing in lots in order to verify the uniformity of the heat treatment in accordance with DIN EN ISO 6506-1 and DIN EN ISO 6506-4 6. Visual examination and dimensional check of each part Requirements depend on the individual application Surface condition: in accordance with DIN EN 10222-1 7. Surface examination [1] of each part in the finished condition [2) 3)]; Examination procedure in accordance with DIN EN 571-1 or DIN EN ISO 9934-1; No indications are permissible that lead to the assumption that cracks are present. 8. Material verification test by a suitable procedure on each part		3.1
Identification marking: in accordance with Sec. 13 of VdTÜV-WB 395/3		

[1] The magnetic particle procedure is the preferred procedure.

[2] Surfaces are considered to be in the finished condition if they have been prepared for final assembly and will not be subjected to further working steps.

[3] If the component manufacturer does no deliver the part in the finished condition then the surface examination at the component manufacturer shall be performed within the framework of assembly testing.

Material Test Sheet	**MTS 1.3**	
Product forms:	Forgings and bars	**Certification:** Test certification in accordance with DIN EN 10204
Materials: 1.4021 [1] + QT700 or QT800	in accordance with DIN EN 10088-3 or DIN EN 10250-4	
1.4057 [1] + QT800	in accordance with DIN EN 10088-3 or DIN EN 10250-4	
1.4122 [1] + QT750	in accordance with DIN EN 10088-3	
Requirements:	in accordance with DIN EN 10088-3 or DIN EN 10250-4	
Test specimen removal and extent of tests:	in accordance with DIN EN 10088-3 or DIN EN 10250-1 and the specifications of this material test sheet	
Tests: 1. Chemical composition Chemical analysis of the melt including declaration of melting process 2. Verification of the heat treatment condition, documenting the temperatures, holding and cooling-down times 3. Tensile test at room temperature 4. Notch bend test at room temperature for each tensile test performed under item 3 of this material test sheet 5. Hardness test on each part when testing in lots in order to verify the uniformity of the heat treatment in accordance with DIN EN ISO 6506-1 and DIN EN ISO 6506-4 6. Visual examination and dimensional check of each part Requirements depend on the individual application 7. Surface examination [2] of each part in the finished condition [3] [4]; Examination procedure in accordance with DIN EN 571-1 or DIN EN ISO 9934-1; No indications are permissible that lead to the assumption that cracks are present. 8. Material verification test on each part applying a suitable procedure.		3.1
Identification marking: in accordance with DIN EN 10088-3 or DIN EN 10250-1		

[1] No welding procedure is permissible for this material.

[2] The magnetic particle procedure is the preferred procedure.

[3] Surfaces are considered to be in the finished condition if they have been prepared for final assembly and will not be subjected to further working steps.

[4] If the component manufacturer does not deliver the part in the finished condition then the surface examination at the component manufacturer shall be performed within the framework of assembly testing.

Material Test Sheet	**MTS 1.4**	
Product forms:	Sheets and strips, s ≤ 6 mm	**Certification:** Test certification in accordance with DIN EN 10204
Materials:	1.4541, 1.4571	
Requirements:	in accordance with DIN EN 10028-7	
Test specimen removal and extent of tests:	in accordance with DIN EN 10028-1 and DIN EN 10028-7 and the specifications of this material test sheet	
Tests: 1. Chemical composition Chemical analysis of the melt including declaration of melting process 2. Verification of the heat treatment condition 3. Tensile test at room temperature 4. Verification of the resistance against intergranular corrosion in accordance with Procedure A of DIN EN ISO 3651-2; one test specimen per melt and heat treatment lot 5. Visual examination and dimensional check of each part Surface condition: Quality Grade 2B Both sides shall be examined for surface imperfections, extent of test 100 % 6. Surface condition If the visual examination performed under item 5 of this material test sheet identifies surface imperfections, liquid penetrant surface examination shall be performed in accordance with DIN EN 571-1; requirements depend on the individual application 7. Material verification test on each part applying a suitable procedure		3.1
Identification marking: in accordance with DIN EN 10028-1		

Material Test Sheet	**MTS 1.5**	
Product forms:	Headed studs SD3 for arc stud welding	**Certification:** not applicable
Materials:	1.4301, 1.4303 in accordance with DIN EN 10088-1	
Requirements:	European Technical Approval (ETA) of the manufacturer, and in accordance with DIN EN ISO 13918	
Test specimen removal and extent of tests:	European Technical Approval (ETA) of the manufacturer, and in accordance with DIN EN ISO 13918	
Tests: The European Technical Approval (ETA) of the manufacturer confirms by a corresponding stamp marking of the headed studs that the requirements are fulfilled and tests have been performed.		Certification stamping
Identification marking: in accordance with European Technical Approval (ETA) of the manufacturer		

Material Test Sheet	**MTS 1.7**	
Product forms:	Sheets	**Certification:** Test certification in accordance with DIN EN 10204
Materials:	Stainless austenitic steel with boron additive	
Requirements:	in accordance with DIN EN 10088-2 and with specifications of this material test sheet	
Test specimen removal and extent of tests:	specifications of this material test sheet	
Tests: 1. Chemical composition Chemical analysis of the melt (% by weight): The requirements shall be specified taking the chosen base material into account. 2. Verification of the heat treatment condition 3. Tensile test at room temperature on one transverse test specimen per melt, per heat treatment load and nominal thickness of every twentieth sheet (rolling); The requirements for $R_{p0,2}$, R_m and A shall be specified. 4. Visual examination and dimensional check of each sheet, requirements depend on the individual application; Surface condition, requirements depend on the individual application 5. Distribution of B, Cr and Ni in the melts The uniform distribution of B, Cr and Ni in austenitic steels shall be verified in at least 9 rollings per melt, statistically distributed over the heat treatment lots. 6. Boron distribution in the sheets The uniformity of the boron distribution in the sheets shall be verified for each melt on one strip from each end of one rolling by a chemical wet-process analysis. 7. Material verification test on each rolling by a suitable procedure, e.g., neutron absorption measurement. This test shall include a qualitative test for boron.		3.1
Identification marking: rubber stamp, only. The following data shall be traceable: Material Melting bath Heat treatment lot Manufacturer		

Material Test Sheet	**MTS 2.1a**	
Product forms:	Seamless or welded steel pipes $p \leq 0.5$ bar, $p \times DN \leq 1000$ or $\leq DN32$	**Certification:** Test certification in accordance with DIN EN 10204
Materials:	1.4541, 1.4550, 1.4571	
Requirements:	in accordance with DIN EN 10216-5 or DIN EN 10217-7	
Test specimen removal and extent of tests:	in accordance with DIN EN 10216-5 or DIN EN 10217-7 and with specifications of this material test sheet	
Tests: 1. Chemical composition Chemical analysis of the melt including declaration of melting process 2. Verification of the heat treatment condition 3. Tensile test at room temperature 4. Mechanical testing of the steel pipes Testing procedure and evaluation in accordance with DIN EN 10216-5 or DIN EN 10217-7 5. Weld seam bending test on welded steel pipes 6. Verification of the resistance against intergranular corrosion in accordance with Procedure A of DIN EN ISO 3651-2; one test specimen per melt and heat treatment lot 7. Visual examination and dimensional check of each steel pipe Requirements depend on the individual application 8. Leak tightness test on each production length applying the internal water pressure test or, alternatively, the eddy-current test in accordance with DIN EN 10246-2 9. No-destructive testing of the weld seam of welded steel pipes, Testing procedure and acceptability class in accordance with DIN EN 10217-7 10. Material verification test on each steel pipe applying a suitable procedure		3.1
Identification marking: in accordance with DIN EN 10216-5 or DIN EN 10217-7		

Material Test Sheet	**MTS 2.1b**	
Product forms:	Seamless or welded fittings (steel pipe bends, reducers [1], T-junctions [1], caps) $p \leq 0.5$ bar, $p \times DN \leq 1000$ or $\leq DN32$	**Certification:** Test certification in accordance with DIN EN 10204
Materials:	1.4541, 1.4550, 1.4571	
Requirements:	in accordance with DIN EN 10253-4	
Test specimen removal and extent of tests:	in accordance with DIN EN 10253-4 and with specifications of this material test sheet	
Tests: 1. Ladle analysis of the initial material 2. Verification of the heat treatment condition 3. Tensile test at room temperature of the basis material if D > 100 mm 4. Weld seam bending test of welded fittings 5. Verification of the resistance against intergranular corrosion in accordance with DIN EN ISO 3651-2, Procedure A, one test specimen per melt and heat treatment lot 6. Hardness test To be tested are 10 % of the fittings if $D \leq 100$ mm, however, no less than three fittings 7. Visual examination and dimensional check of each fitting Requirements depend on the individual application, however, tolerances shall be at least in accordance with DIN EN 10253-4 Surface condition: The fittings shall be pickled 8. Non-destructive testing of the weld seam of welded fittings Testing procedure in accordance with DIN EN 10253-4 and acceptability class in line with DIN EN 10217-7 9. Material verification test by a suitable procedure on each fitting		3.1
Identification marking: in accordance with DIN EN 10253-4		
[1] D is the respectively larger connecting cross-section		

Material Test Sheet	**MTS 3.1**	
Product forms:	Bolts and nuts ≥ M6 through ≤ M39 Austenitic steels: strength grades 50, 70 and 80 Martensitic steels: strength grade 80	**Certification:** not applicable
Materials:	Steel types A2, A3, A4, A5 and C3	
Requirements:	in accordance with DIN EN ISO 3506-1 (bolts), DIN EN ISO 3506-2 (nuts)	
Test specimen removal and extent of tests:	in accordance with DIN EN ISO 3506-1 (bolts), DIN EN ISO 3506-2 (nuts) and DIN EN ISO 3269	
The surveillance of the manufacturer by the authorized expert in accordance with VdTÜV-Procedure Specification Materials 1253/4 and the corresponding stamp marking of the bolts and nuts confirms that the requirements are fulfilled and the tests have been performed.		Certification stamping
Identification marking: in accordance with VdTÜV- Specification Materials 1253/4		

Material Test Sheet	**MTS 3.2**	
Product forms:	Bolts and nuts ≥ M6 through ≤ M39 (not in contact with fluid media)	**Certification:** not applicable
Materials:	Bolts: strength grades 5.6 and 8.8 Nuts: strength grades 5 and 8	
Requirements:	in accordance with DIN EN ISO 898-1 (bolts), and DIN EN 20898-2 (nuts)	
Test specimen removal and extent of tests:	in accordance with DIN EN ISO 898-1 (bolts), DIN EN 20898-2 (nuts) and DIN EN ISO 3269	
The surveillance of the manufacturer by the authorized expert in accordance with VdTÜV-Procedure Specification Materials 1253/4 and the corresponding stamp marking of the bolts and nuts confirms that the requirements are fulfilled and the tests have been performed.		Certification stamping
Identification marking: in accordance with VdTÜV-Procedure Specification Materials 1253/4		
N o t e : The bolts and nuts shall be provided with a surface protective coating.		

Material Test Sheet	**MTS 4.1a**	
Product forms:	Sheets, strips, wide flats, profiles [1] and rolled bars (not in contact with fluid media)	**Certification:** Test certification in accordance with DIN EN 10204
Materials:	S235JR [2] (1.0038), S235J2 (1.0117), S355J2 (1.0577)	
Requirements:	in accordance with DIN EN 10025-2 and with specifications of this material test sheet	
Test specimen removal and extent of tests:	in accordance with DIN EN 10025-1, DIN EN 10025-2 (tests performed after melting), and DIN EN 10164, and with specifications of this material test sheet	
Tests: 1. Chemical composition Chemical analysis of the melt including detailed carbon equivalent value (CEV). 2. Verification of the heat treatment condition 3. Tensile test at room temperature 4. Tensile tests in the direction perpendicular to the major surface at room temperature of sheets, wide flats and profiles made of S235J2 and S355J2 with s ≥ 15 mm, provided, this is required according to Section 7.2 para. 3; to be performed on three test specimens in accordance with DIN EN 10164 per rolling in the case of sheets, and on three test specimens for each tensile test performed under item 3 of this MTS in the case of wide flats and profiles – the fracture constriction to be verified shall correspond to Quality Grade Z25 in accordance with DIN EN 10164 5. Notched bar impact test at -20 °C on all product forms made of S235J2 and S355J2, provided, s ≥ 6 mm; one set of three test specimens for each tensile test performed under item 3 of this MTS 6. Ultrasonic testing of the major surfaces on all parts on which the test under item 4 of this MTS was performed; in the case of sheets and wide flats this test must verify Quality Class S_1 in accordance with DIN EN 10160, and in the case of profiles Quality Class 2.3 in accordance with DIN EN 10306 7. Visual examination and dimensional check of each part; Requirements depend on the individual application Surface condition: in the case of sheets, strips and wide flats, Quality Class B3 in accordance with DIN EN 10163-2 or, in the case of profiles, Quality Class D3 in accordance with DIN EN 10163-3	3.1
Identification marking: in accordance with DIN EN 10025-1 and, additionally, the Quality Class Z25 in accordance with DIN EN 10164 (if this was verified)		

[1] Profiles and steel pipes, cf. MTS 4.1c

[2] This material shall not be used in those cases where, as specified in Section 7.3 para. 3, improved characteristics are required in the direction perpendicular to the major surface

Material Test Sheet	**MTS 4.1b**	
Product forms:	Sheets (not in contact with fluid media)	**Certification:** Test certification in accordance with DIN EN 10204
Materials:	P265GH (1.0425)	
Requirements:	in accordance with DIN EN 10028-2 and with specifications of this material test sheet	
Test specimen removal and extent of tests:	in accordance with DIN EN 10028-1 and DIN EN 10164 and with specifications of this material test sheet	
Tests: 1. Chemical composition Chemical analysis of the melt including detailed carbon equivalent value (CEV); in the case of a sheet thickness ≤ 100 mm: CEV max. 0.4 in the case of a sheet thickness > 100 mm CEV max. 0.42 2. Verification of the heat treatment condition 3. Tensile test at room temperature 4. Tensile tests in the direction perpendicular to the major surface at room temperature of sheets with s ≥ 15 mm, provided, this is required according to Section 7.2 para. 3; performed on three test specimens per rolling in accordance with DIN EN 10164 – the fracture constriction to be verified shall correspond to Quality Grade Z25 in accordance with DIN EN 10164 5. Notched bar impact test at -20 °C, provided, s ≥ 6 mm; one set of three test specimens for each tensile test specified under item 3 of this MTS 6. Ultrasonic testing of the major surfaces of every rolling on which the test specified under item 4 of this MTS was performed; this test must verify a Quality Class S_1 in accordance with DIN EN 10306 7. Visual examination and dimensional check of each part; requirements depend on the individual application Surface condition: Quality class B3 in accordance with DIN EN 10163-2		3.1
Identification marking: in accordance with DIN EN 10028-1 and, additionally, the Quality Class Z25 in accordance with DIN EN 10164 (if this was verified)		

Material Test Sheet	**MTS 4.1c**	
Product forms:	Hot finished profiles (seamless or welded) (not in contact with fluid media)	**Certification:** Test certification in accordance with DIN EN 10204
Materials:	S235JRH (1.0039), S355J2H (1.0576)	
Requirements:	in accordance with DIN EN 10210-1 and DIN EN 10210-2	
Test specimen removal and extent of tests:	in accordance with DIN EN 10210-1 and with specifications of this material test sheet	
Tests: 1. Chemical composition Chemical analysis of the melt including detailed the carbon equivalent value (CEV), 2. Verification of the heat treatment condition 3. Tensile test at room temperature on each melt, dimension and heat treatment lot 4. Tensile tests in the direction perpendicular to the major surface at room temperature of profiles with s ≥ 15 mm, provided, this is required according to Section 7.2 para. 3; to be performed in accordance with DIN EN 10164 on three test specimens for each tensile test performed under item 3 of this MTS – the fracture constriction to be verified shall correspond to Quality Grade Z25 in accordance with DIN EN 10164 5. Notched bar impact test at -20 °C on profile made of S355J2H, provided, s ≥ 6 mm; one set of three test specimens for each tensile test specified under item 3 of this MTS 6. Ultrasonic testing of each profile on which the test specified under item 4 of this MTS was performed; this test must verify a Quality Class 2.3 in accordance with DIN EN 10306 7. Non-destructive testing of the weld seam of each welded profile Testing procedure and acceptability class in accordance with DIN EN 10210-1 8. Visual examination and dimensional check in line with DIN EN 10210-2; no weld repairs of the profile body are permissible; requirements depend on the individual application		3.1
Identification marking: in accordance with DIN EN 10210-1		

Material Test Sheet	**MTS 4.2**	
Product forms:	Headed studs SD1 for arc stud welding	**Certification:** not applicable
Materials:	S235J2 + C450 in accordance with DIN EN 10025-2 and DIN EN ISO 13918	
Requirements:	European Technical Approval (ETA) of the manufacturer, and in accordance with DIN EN ISO 13918	
Test specimen removal and extent of tests:	European Technical Approval (ETA) of the manufacturer, and in accordance with DIN EN ISO 13918	
The European Technical Approval (ETA) of the manufacturer and the corresponding stamp marking of the headed studs confirms that the requirements are fulfilled and the tests have been performed.		stamping
Identification marking: in accordance with the European Technical Approval (ETA) of the manufacturer		

Appendix B

Regulations Referred to in this Safety Standard

(Regulations referred to in this safety standard are only valid in the version cited below. Regulations which are referred to within these regulations are valid only in the version that was valid when the later regulations were established or issued.)

AtG		Act on the peaceful utilization of atomic energy and the protection against its hazards (Atomic Energy Act – AtG) of December 23, 1959, revised version of July 15, 1985 (BGBl. I p. 1565), most recently changed by Article 1 of the Act of July 31, 2011 (BGBl. I p. 1704)
StrlSchV		Ordinance on the protection from damage by ionizing radiation (Radiological Protection Ordinance – StrlSchV) of July 20, 2001 (BGBl. I p. 1714; 2002 I p. 1459), most recently changed by Article 1 of the Act of October 4, 2011 (BGBl. I p. 2000)
Safety Criteria	(1977-10)	Safety criteria for nuclear power plants by the German Federal Minster of Interior of October 21, 1977 (BAnz No. 206 of November 3, 1977)
Design Basis Accident Guidelines	(1983-10)	Guidelines for the assessment of the design of nuclear power plants with pressurized water reactors against design basis accidents as defined in Sec. 28, para. 3 StrlSchV (Design Basis Accident Guidelines) of October 18, 1983 (BAnz No. 245a of December 31, 1983)
KTA 1401	(1996-06)	General requirements regarding quality assurance
KTA 2201.1	(2011-11)	Design of nuclear power plants against seismic events; Part 1: Principles
KTA 3201.2	(1996-06)	Components of the Reactor Coolant Pressure Boundary of Light Water Reactors; Part 2: Design and Analysis
KTA 3303	(1990-06)	Heat removal systems for fuel assembly storage fuel pools in nuclear power plants with light water reactors
KTA 3602	(2003-11)	Storage and handling of fuel assemblies and associated items in nuclear power plants with light water reactors
KTA 3902	(1999-06)	Design of lifting equipment in nuclear power plants
KTA 3905	(1999-06)	Load attaching points on loads in nuclear power plants
DIN 25449	(2008-02)	Reinforced and prestressed concrete components in nuclear facilities –Safety concept, actions, design and construction
DIN EN 571-1	(1997-03)	Non-destructive testing - Penetrant testing - Part 1: General principles; German version EN 571-1:1997
DIN EN 1990 in connection with	(2010-12)	Eurocode: Basis of structural design; German version EN 1990:2002 + A1:2005 + A1:2005/AC:2010
DIN EN 1990/NA	(2010-12)	National Annex - Nationally determined parameters - Eurocode: Basis of structural design
DIN EN 1992-1-1 in connection with	(2011-01)	Eurocode 2: Design of concrete structures - Part 1-1: General rules and rules for buildings; German version EN 1992-1-1:2004 + AC:2010
DIN EN 1992-1-1/NA	(2011-01)	National Annex - Nationally determined parameters - Eurocode 2: Design of concrete structures - Part 1-1: General rules and rules for buildings
DIN EN 1993-1-1 in connection with	(2010-12)	Eurocode 3: Design of steel structures - Part 1-1: General rules and rules for buildings; German version EN 1993-1-1: 2005 + AC:2009
DIN EN 1993-1-1/NA	(2010-12)	National Annex - Nationally determined parameters - Eurocode 3: Design of steel structures - Part 1-1: General rules and rules for buildings
DIN EN 1993-1-3 in connection with	(2010-12)	Eurocode 3: Design of steel structures - Part 1-1: General rules and rules for buildings; German version EN 1993-1-1:2005 + AC:2009
DIN EN 1993-1-3/NA	(2010-12)	National Annex - Nationally determined parameters - Eurocode 3: Design of steel structures - Part 1-3: General rules - Supplementary rules for cold-formed members and sheeting
DIN EN 1993-1-4 in connection with	(2007-02)	Eurocode 3: Design of steel structures - Part 1-4: General rules - Supplementary rules for stainless steels; German version EN 1993-1-4:2006

DIN EN 1993-1-4/NA	(2010-12)	National Annex - Nationally determined parameters - Eurocode 3: Design of steel structures - Part 1-4: General rules - Supplementary rules for stainless steels
DIN EN 1993-1-5 in connection with	(2010-12)	Eurocode 3: Design of steel structures - Part 1-5: Plated structural elements; German version EN 1993-1-5:2006 + AC:2009
DIN EN 1993-1-5/NA	(2010-12)	National Annex - Nationally determined parameters - Eurocode 3: Design of steel structures - Part 1-5: Plated structural elements
DIN EN 1993-1-6 in connection with	(2010-12)	Eurocode 3: Design of steel structures - Part 1-6: Strength and stability of shell structures; German version EN 1993-1-6:2007 + AC:2009
DIN EN 1993-1-6/NA	(2010-12)	National Annex - Nationally determined parameters - Eurocode 3: Design of steel structures - Part 1-6: Strength and stability of shell structures
DIN EN 1993-1-7 in connection with	(2010-12)	Eurocode 3: Design of steel structures - Part 1-7: Plated structures subject to out of plane loading; German version EN 1993-1-7:2007 + AC:2009
DIN EN 1993-1-7/NA	(2010-12)	National Annex - Nationally determined parameters - Eurocode 3: Design of steel Structures - Part 1-7: Plated structures subject to out of plane loading
DIN EN 1993-1-8 in connection with	(2010-12)	Eurocode 3: Design of steel structures - Part 1-8: Design of joints; German version EN 1993-1-8:2005 + AC:2009
DIN EN 1993-1-8/NA	(2010-12)	National Annex - Nationally determined parameters - Eurocode 3: Design of steel structures - Part 1-8: Design of joints
DIN EN 1993-1-9 in connection with	(2010-12)	Eurocode 3: Design of steel structures - Part 1-9: Fatigue; German version EN 1993-1-9:2005 + AC:2009
DIN EN 1993-1-9/NA	(2010-12)	National Annex - Nationally determined parameters - Eurocode 3: Design of steel structures - Part 1-9: Fatigue
DIN EN 1993-1-10 in connection with	(2010-12)	Eurocode 3: Design of steel structures - Part 1-10: Material toughness and through-thickness properties; German version EN 1993-1-10:2005 + AC:2009
DIN EN 1993-1-10/NA	(2010-12)	National Annex - Nationally determined parameters - Eurocode 3: Design of steel structures - Part 1-10: Material toughness and through-thickness properties
DIN EN 1993-1-12 in connection with	(2010-12)	Eurocode 3: Design of steel structures - Part 1-12: Additional rules for the extension of EN 1993 up to steel grades S700; German version EN 1993-1-12:2007 + AC:2009
DIN EN 1993-1-12/NA	(2011-08)	National Annex - Nationally determined parameters - Eurocode 3: Design of steel structures - Part 1-12: Additional rules for the extension of EN 1993 up to steel grades S700
DIN EN 10025-1	(2005-02)	Hot rolled products of structural steels - Part 1: General technical delivery conditions; German version EN 10025-1:2004
DIN EN 10025-2	(2005-04)	Hot rolled products of structural steels - Part 2: Technical delivery conditions for non-alloy structural steels; German version EN 10025-2:2011
DIN EN 10028-1	(2009-07)	Flat products made of steels for pressure purposes - Part 1: General requirements; German version EN 10028-1:2007+A1:2009
DIN EN 10028-2	(2009-09)	Flat products made of steels for pressure purposes - Part 2: Non-alloy and alloy steels with specified elevated temperature properties; German version EN 10028-2:2009
DIN EN 10028-7	(2008-02)	Flat products made of steels for pressure purposes - Part 7: Stainless steels; German version EN 10028-7:2007
DIN EN 10045-1	(1991-04)	Metallic materials; Charpy impact test; Part 1: Test procedure; German version EN 10045-1:1990
DIN EN 10088-1	(2005-09)	Stainless steels - Part 1: List of stainless steels; German version EN 10088-1:2005
DIN EN 10088-2	(2005-09)	Stainless steels - Part 2: Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for general purposes; German version EN 10088-2:2005
DIN EN 10088-3	(2005-09)	Stainless steels - Part 3: Technical delivery conditions for semi-finished products, bars, rods, wire, sections and bright products of corrosion resisting steels for general purposes; German version EN 10088-3:2005
DIN EN 10160	(1999-09)	Ultrasonic testing of steel flat product of thickness equal to or greater than 6 mm (reflection method); German version EN 10160:1999

DIN EN 10163-2	(2005-03)	Delivery requirements for surface conditions of hot-rolled steel plates, wide flats and sections - Part 2: Plate and wide flats; German version EN 10163-2:2004
DIN EN 10163-3	(2005-03)	Delivery requirements for surface condition of hot-rolled steel plates, wide flats and sections - Part 3: Sections; German version EN 10163-3:2004
DIN EN 10164	(2005-03)	Steel products with improved deformation properties perpendicular to the surface of the product - Technical delivery conditions; German version EN 10164:2004
DIN EN 10204	(2005-01)	Metallic products - Types of inspection documents; German version EN 10204:2004
DIN EN 10210-1	(2006-07)	Hot finished structural hollow sections of non-alloy and fine grain steels - Part 1: Technical delivery conditions; German version EN 10210-1:2006
DIN EN 10210-2	(2006-07)	Hot finished structural hollow sections of non-alloy and fine grain steels - Part 2: Tolerances, dimensions and sectional properties; German version EN 10210-2:2006
DIN EN 10216-5	(2004-11)	Seamless steel tubes for pressure purposes - Technical delivery conditions - Part 5: Stainless steel tubes; German version EN 10216-5:2004
in connection with	(2008-06)	Corrigendum to DIN EN 10216-5:2004-11; German version EN 10216-5:2004/AC:2008
DIN EN 10217-7	(2005-05)	Welded steel tubes for pressure purposes - Technical delivery conditions - Part 7: Stainless steel tubes; German version EN 10217-7:2005
DIN EN 10222-1	(2002-07)	Steel forgings for pressure purposes - Part 1: General requirements for open die forgings (includes Amendment A1:2002); German version EN 10222-1:1998 + A1:2002
DIN EN 10222-5	(2000-02)	Steel forgings for pressure purposes - Part 5: Martensitic, austenitic and austenitic-ferritic stainless steels; German version EN 10222-5:1999
in connection with	(2004-08)	Corrigenda in DIN Gazette (*DIN-Anzeiger*) for Technical Standards 8/2004
DIN EN 10246-2	(2000-06)	Non-destructive testing of steel tubes - Part 2: Automatic eddy current testing of seamless and welded (except submerged arc-welded) austenitic and austenitic-ferritic steel tubes for verification of hydraulic leak-tightness; German version EN 10246-2:2000
DIN EN 10250-1	(1999-12)	Open die steel forgings for general engineering purposes - Part 1: General requirements; German version EN 10250-1:1999
DIN EN 10250-4	(2000-02)	Open die steel forgings for general engineering purposes - Part 4: Stainless steels; German version EN 10250-4:1999
in connection with	(2008-12)	Corrigendum to DIN EN 10250-4:2000-02
DIN EN 10253-4	(2008-06)	Butt-welding pipe fittings - Part 4: Wrought austenitic and austenitic-ferritic (duplex) stainless steels with specific inspection requirements; German version EN 10253-4:2008
in connection with	(2009-11)	Corrigendum to DIN EN 10253-4:2008-06; German version EN 10253-4:2008/AC:2009
DIN EN 10272	(2008-01)	Stainless steel bars for pressure purposes; German version EN 10272:2007
DIN EN 10306	(2002-04)	Iron and steel - Ultrasonic testing of H beams with parallel flanges and IPE beams; German version EN 10306:2001
DIN EN 14532-1	(2005-02)	Welding consumables - Test methods and quality requirements - Part 1: Primary methods and conformity assessment of consumables for steel, nickel and nickel alloys; German version EN 14532-1:2004
DIN EN 14532-2	(2005-02)	Welding consumables - Test methods and quality requirements - Part 2: Supplementary methods and conformity assessment of consumables for steel, nickel and nickel alloys; German version EN 14532-2:2004
DIN EN 20898-2	(1994-02)	Mechanical properties of fasteners; Part 2: nuts with specified proof load values; coarse thread (ISO 898-2:1992); German version EN 20898-2:1993
DIN EN ISO 898-1	(2009-08)	Mechanical properties of fasteners made of carbon steel and alloy steel – Part 1: Bolts, screws and studs with specified property classes - Coarse thread and fine pitch thread (ISO 898-1:2009/DAM 1:2010); German version EN ISO 898-1:2009
DIN EN ISO 3269	(2000-11)	Fasteners - Acceptance inspection (ISO 3269:2000); German version EN ISO 3269:2000

DIN EN ISO 3506-1	(2010-04)	Mechanical properties of corrosion-resistant stainless steel fasteners - Part 1: Bolts, screws and studs (ISO 3506-1:2009); German version EN ISO 3506-1:2009
DIN EN ISO 3506-2	(2010-04)	Mechanical properties of corrosion-resistant stainless steel fasteners - Part 2: Nuts (ISO 3506-2:2009); German version EN ISO 3506-2:2009
DIN EN ISO 3651-2	(1998-08)	Determination of resistance to intergranular corrosion of stainless steels - Part 2: Ferritic, austenitic and ferritic-austenitic (duplex) stainless steels - Corrosion test in media containing sulfuric acid (ISO 3651-2:1998); German version EN ISO 3651-2:1998
DIN EN ISO 6506-1	(2006-03)	Metallic materials - Brinell hardness test - Part 1: Test method (ISO 6506-1:2005); German version EN ISO 6506-1:2005
DIN EN ISO 6506-4	(2006-03)	Metallic materials - Brinell hardness test - Part 4: Table of hardness values (ISO 6506-4:2005); German version EN ISO 6506-4:2005
DIN EN ISO 6892-1	(2009-12)	Metallic materials - Tensile testing - Part 1: Method of test at room temperature (ISO 6892-1:2009); German version EN ISO 6892-1:2009
DIN EN ISO 9001	(2008-12)	Quality management systems - Requirements (ISO 9001:2008); Trilingual version EN ISO 9001:2008
in connection with	(2009-12)	Corrigendum to DIN EN ISO 9001:2008-12; Trilingual version EN ISO 9001:2008/AC:2009
DIN EN ISO 9934-1	(2002-03)	Non-destructive testing - Magnetic particle testing - Part 1: General principles (ISO 9934-1:2001); German version EN ISO 9934-1:2001
in connection with	(2004-03)	Corrigenda in DIN Gazette (*DIN-Anzeiger*) for Technical Standards 3/2004
DIN EN ISO 13918	(2008-10)	Welding - Studs and ceramic ferrules for arc stud welding (ISO 13918:2008); German version EN ISO 13918:2008
DIBt Construction Products List A Part 1		*Deutsches Institut für Bautechnik (DIBt)* Annual publication of the construction products for which technical rules exist (regulated construction products), of the rules themselves, the required attestation of conformity and, in case of deviations, the necessary verifications of applicability
DIBt General Construction Approval Z-30.3-6	(2009-04)	*Deutsches Institut für Bautechnik* (DIBt) General national construction approval Z-30.3-6 of April 20, 2009: Products, fasteners and components out of stainless steels
VdTÜV-Specification Materials 1253/4	(2010-12)	VdTÜV-Specification Materials List of the manufacturers and processors of screws and nuts approved by technical supervisory organizations (TÜV), however, waiving audit certification
VdTÜV-WB 395/3	(2010-09)	VdTÜV Material Sheet Weldable, rolled and forged martensitic steel X3CrNiMo 13-4; Material No. 1.4313; Sectional steel and steel bars, forged products