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of the
Nuclear Safety Standards Commission (KTA)

KTA 3905 (2020-12)

Load Attachment Points on Loads in Nuclear Power Plants

(Lastanschlagpunkte an Lasten in Kernkraftwerken)

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

Editor:

KTA-Geschaeftsstelle c/o Bundesamt fuer die Sicherheit der nuklearen
Entsorgung (BASE) • Willy-Brandt-Strasse 5 • 38226 Salzgitter • Germany
Telephone +49-30-18-4321-2907 • E-Mail kta-gs@bfe.bund.de

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Load Attachment Points on Loads in Nuclear Power Plants

KTA 3905

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PLEASE NOTE: Only the original German version of this safety standard represents the joint resolution of the 35-member Nuclear Safety Standards Commission (Kerntechnischer Ausschuss, KTA). The German version was made public in the Federal Gazette (Bundesanzeiger) of January 20th, 2021. Copies of the German versions of the KTA safety standards may be mail-ordered through the Wolters Kluwer Deutschland GmbH (info@wolterskluwer.de). Downloads of the English translations are available at the KTA website (<http://www.kta-gs.de>).

All questions regarding this English translation should please be directed to the KTA office:

KTA-Geschäftsstelle c/o BASE, Willy-Brandt-Str. 5, D-38226 Salzgitter, Germany or kta-gs@bfe.bund.de

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, the 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 objective to specify safety-related requirements, compliance of which provides the necessary precautions in accordance with the state of the art in science and technology against damage arising from the construction and operation of the facility (Sec. 7 para. 2 subpara. 3 Atomic Energy Act - AtG) in order to achieve the fundamental safety functions specified in the Atomic Energy Act, the Radiation Protection Act (StrlSchG) and the Radiological Protection Ordinance (StrlSchV) and further detailed in the Safety Requirements for Nuclear Power Plants (SiAnf) as well as in the Interpretations on the Safety Requirements for Nuclear Power Plants.

(2) Based on the Safety Requirements for Nuclear Power Plants (SiAnf) and the Interpretations on the Safety Requirements for Nuclear Power Plants, this Safety Standard specifies the requirements to be derived therefrom for load attachment points. Regarding the danger potential the general provisions and

- a) additional requirements or
 - b) increased requirements
- for load attachment points as well as
- c) special requirements for load attachment points on core components
- shall be taken into account.

(3) This Safety Standard deals with the design and analysis, materials, tests and inspections, operation and maintenance including documentation of load attachment points functioning as connecting element between load carrying device and load.

(4) Special requirements specific to a component are not dealt with here, but shall be taken into account where required.

(5) General requirements regarding quality assurance are specified in Safety Standard KTA 1401. Quality assurance requirements exceeding those of KTA 1401 are laid down in this Safety Standard for each individual case.

1 Scope

(1) This Safety Standard shall apply to load attachment points on loads which are handled in nuclear power plants during specified normal operation and must comply with the special provisions of section 4.

(2) This Safety Standard shall furthermore apply to load attachment points of the following core components:

- a) fuel elements, control elements and in-core instrumentation lances for pressurized water reactors,
- b) fuel elements, control rods and fuel assembly channels for boiling water reactors.

(3) Load attachment points on core component encapsulations are to be considered load attachment points on core components.

(4) This Safety Standard does not apply to:

- a) load attachment points on reactor pressure vessel internals

Note:

Load attachment points on reactor pressure vessel internals are covered by KTA 3204.

- b) load attachment points on containers for the storage, handling and internal transport of radioactive substances, which meet the requirements of KTA 3604.

2 Definitions

(1) Load attachment point (LAP)

The load attachment point is the connecting element between load carrying device and load and is either

- a) an integral part of the load or
- b) bolted on or
- c) welded on or
- d) anchored in the concrete in the case of structural concrete components

Note:

The delimitation between load attachment point and load is described in **Annex C** with reference to examples.

(2) Authorized inspectors

Authorized inspectors for the tests and inspections for the purpose of this Safety Standard are the following on the basis of nuclear, building or traffic legislation:

- a) authorized inspectors consulted by the licensing or supervisory authority in accordance with § 20 of the Atomic Energy Act,
- b) authorized inspectors from the institution competent under the building code of the respective State or the inspecting engineers put in charge by this institution,
- c) authorized inspectors from the institution competent under the traffic legislation or the authorized inspector consulted by this agency.

3 General provisions

Load attachment points shall at least comply with the generally accepted engineering standards.

4 Special provisions

4.1 Classification

The classification of the load attachment points with respect to the additional or increased requirements shall be specified within the framework of the nuclear licensing and supervisory procedure. Examples for the classification and for the procedural steps of classification are given in **Annex D**.

4.2 Load attachment points with additional requirements

If, in the course of transportation of nuclear fuel, other radioactive substances, radioactive plant components or other loads, a failure of the load attachment point is expected to lead

- a) to the immediate danger of a release of radioactivity with a subsequent radioactive exposure of persons in the plant subjected to an effective dose by inner exposure exceeding 1 mSv or to an external exposure exceeding 5 mSv or
- b) to a loss of reactor coolant which cannot be isolated, or to a detrimental effect on, and going beyond the redundancy of, the safety equipment which is necessary to shut down the reactor at any time, to maintain the reactor in the shut-down condition or to remove residual heat, and no dangers as per section 4.3 need be expected,

then the additional requirements specified in this Safety Standard that exceed the requirements under section 3 shall apply to these load attachment points.

4.3 Load attachment points with increased requirements

If, in the course of transportation of nuclear fuel, other radioactive substances, radioactive components or other loads, a failure of the lifting equipment is expected to lead

- a) to a criticality accident
- or
- b) to the danger of a release of radioactive substances with the maximum allowable discharge into the atmosphere may be expected,

ceeded as laid down in the license or the radioactive exposure of individual persons of the population in the nuclear power plant environment may exceed the limit values of the Radiological Protection Ordinance (StrlSchV)

then more stringent requirements specified in this Safety Standard that exceed the requirements under section 3 shall apply to these load attachment points.

4.4 Load attachment points on core components

Load attachment points on core components according to clause 1 (2) shall, in addition to the general provisions of section 3, meet the requirements of the pertinent sections of this Safety Standard.

5 Analytical and structural design

5.1 General

5.1.1 Load assumptions

(1) In the case of statically indeterminate systems where the calculated load distribution over all load attachment points is not ensured by the load carrying device, the maximum possible load, however, at least one half of the total load, shall be proved for each load attachment point.

(2) Where additional forces, e.g. as a result of breaking loose, static friction or tilting, cannot be precluded by design measures, these forces shall be taken into account.

(3) Ambient conditions such as pressure, temperature, fluid and radiation exposure shall be considered in the design.

(4) Component-specific requirements for the analytical and structural design, calculation, materials, tests and inspections, operation and maintenance shall be considered.

(5) For load attachment points used as support and attachment on the transportation means during transportation outside the nuclear power plant, the loadings resulting from transports inside and outside the nuclear power plant shall be considered in the fatigue analysis.

(6) For load attachment points no verification of adequate protection against external impacts is required.

5.1.2 Stress analysis

(1) The following analytical proofs shall basically be performed: stress analysis and fatigue analysis.

A fatigue analysis is not required

- a) for structural steel components
 - aa) which are designed according to DIN 15018-1 provided a number of stress cycles $N_G = 2 \cdot 10^4$ will not be exceeded,
 - ab) which are designed according to the standard series DIN EN 13001 provided a fatigue analysis may be omitted for the respective case of application in compliance with this standard series,
- b) for other parts of load attachment points provided a number of 6,000 stress cycles will not be exceeded.

Notes:

(1) Structural steel components for the purposes of this Safety Standard are structural members made of welded or screwed together steel plates or rolled steel sections.

(2) Other parts of load attachment points refer, inter alia, to parts where a stress evaluation on the basis of nominal stresses is not purposeful.

The number of stress cycles shall be determined in accordance with clause 5.1.3.

(2) Analytical proofs may be performed by calculation or experimentally or as a combination of calculation and experiments.

(3) The stress evaluation shall basically be based on nominal stresses. Where a stress evaluation on the basis of nominal stresses is not purposeful (e.g. in the case of volume-type parts with complex cross-sections and notches), the stress evaluation shall be made according to specific requirements for each individual case.

Note:

For bolted load attachment points of transport vessels for radioactive substances to be used within and outside nuclear power plants the requirements for the analytical proofs as well as the evaluation criteria for the stress analysis and the fatigue analysis are defined e.g. in the Guideline BAM-GGR 012.

(4) In the case of connections made with bolts to be re-assembled upon disassembly, the following applies in addition to (1):

- a) Where a fatigue analysis is to be carried out as per (1), the stress cycles resulting from disassembly and re-assembly operations shall be taken into account in the analysis.
- b) Where no fatigue analysis is required as per subcl. (1) and a maximum of 10 disassembly and re-assembly operations is carried out, an fatigue analysis may be waived.
- c) Where more than 10 disassembly and re-assembly operations are carried out, a fatigue analysis shall be carried out independently of the requirements of subcl. (1). In this case, both the stress cycles from operational loadings and from disassembly and re-assembly operations shall be taken into account.

5.1.3 Determination of the load collective

(1) As regards the fatigue analysis, the stresses in the part shall be calculated in due consideration of the load assumptions according to cl. 5.1.1 and be classified as to their magnitudes. With the related number of stress cycles the load collective shall be determined.

(2) In doing so, the number of stress cycles shall be calculated in accordance with the following equation

$$N_G = U \cdot Z_{Sch} \cdot k_a \quad (5.1-1)$$

using $k_a = 3$

$Z_{Sch} = 10$ for hoists with creep speed and for converter drives

$Z_{Sch} = 20$ for other drives

Where

k_a number of stress cycles as a result of a switching operation

N_G number of (dynamic) stress cycles

U number of working cycles; a working cycle is the process between taking up and setting down of the load

Z_{Sch} number of switching operations per working cycle (switching on to accelerate corresponds to one switching operation; switching over to braking, likewise).

(3) The cyclic history for the strength analysis shall be converted by the elementary Miner's Rule (linear damage accumulation at continuous stress number diagram in a double logarithmic representation in accordance with sections B 1.2.1.3 and B 1.2.2.1 of KTA 3902) to a damage-equivalent single-step load collective. The stress amplitude belonging to N_G shall be determined under consideration of the dynamic factor specified in the following sections for the individual parts. Where the stresses within a working cycle are unknown, the maximum stress amplitude after connection of the load shall be assumed as remaining constant over the entire working cycle.

(4) If the actual stresses within a working cycle are known from experimental investigations or from appropriate estimation

tion of the cyclic stressing history with suitable analytical models (e.g. taking account of the vibration energy consumed by the work loss being impressed on the system by the coupling impact), the fatigue analysis may be performed on this basis.

5.1.4 Structural design

5.1.4.1 Load attachment points according to section 4.2 or 4.3

(1) The following shall apply to structural steel components and weld seams:

- a) the requirements of DIN 15018-1 and DIN 15018-2 when using the global safety factor concept,
- b) the relevant stipulations of standard series DIN EN 13001 when using the partial safety factors concept.

(2) The requirements in accordance with VDI 2230 Sheet 1 apply to the construction of bolted connections.

(3) Only those load attachment points are permissible which are either an integral part of the load, are bolted on or welded on and, in the case of concrete parts, are anchored in the concrete.

(4) The load attachment point shall be designed such that it can only be positively attached to the lifting equipment. Safeguards shall be provided to prevent any inadvertent release of the load carrying device from the load attachment point.

(5) Load attachment points shall be constructed or marked such that they cannot be used in an inadmissible manner and the ergonomic requirements of KTA 3902, section 4.7, are satisfied in combination with the load carrying device.

(6) In the case of welded-on load attachment points the design shall ensure that either

- a) the stress level in the weld seam does not exceed 80 % of the allowable stress (weld quality not to be proved)

or

- b) non-destructive testing of the attachment weld volume is possible.

(7) Load-carrying weld seams shall satisfy the requirements of quality level B acc. to DIN EN ISO 5817 or DIN EN ISO 13919-1.

(8) When employing rope slings in accordance with DIN EN 13414-1 and DIN EN 13414-2 or chain slings in accordance with DIN EN 818-4 for load suspension devices and lifting accessories, only 50 % of the working load limit specified in these standards shall be used. This shall be taken into account in the structural design of load attachment points.

(9) The surfaces of load attachment points shall be such that they can be easily decontaminated.

5.1.4.2 Load attachment points according to section 4.4

(1) The load attachment point shall be designed such that it can only be positively attached to the lifting equipment. Safeguards shall be provided to prevent any inadvertent release of the load carrying device from the load attachment point.

(2) For weld seams the provisions of the drawings and related specifications apply.

(3) The requirements in accordance with VDI 2230 Sheet 1 apply to the construction of bolted connections.

5.2 Structural steel components

5.2.1 Design principles

(1) For the application of this Safety Standard, two verification methods are permitted for structural steel components:

- a) method using a global safety factor (σ_{zul} concept) according to DIN 15018-1

and

- b) method using partial safety factors according to the standard series DIN EN 13001.

(2) The simultaneous use of both methods within the entire verification process for a load attachment point is not allowed.

5.2.2 Additional requirements

5.2.2.1 Dynamic factor

(1) The dead weight of the load shall be multiplied by a dynamic factor of $\psi = 1.35$ for determination of the load assumptions.

(2) Where the maximum hoist speed $v_{h,max}$ is known, instead of the dynamic factor as per sub-clause (1) above the following values may be used

- a) the dynamic factor¹ resulting from lifting class H3 according to DIN 15018-1 when using the global safety factor concept,

- b) the dynamic factor

$$\Phi_2 = 1.3 + 0.396 \cdot v_{h,max} \quad (5.2-1)$$

for the verification according to DIN 13001-2 when using the partial safety factors concept.

For $v_{h,max}$ the maximum hoisting speed in m/s decisive for the specific load case shall be taken.

(3) Where a dynamic factor less than that of sub-clauses (1) or (2) is to be used, the maximum dynamic load factor occurring at the load attachment point during one working cycle shall be determined by means of calculation or experimentally in each individual case. As regards the determination of the dynamic factor this dynamic load factor shall be multiplied by a safety factor of 1.12.

5.2.2.2 Stress analysis

The stress analysis shall be carried out

- a) as general stress analysis in accordance with DIN 15018-1 for the "main forces" load case H

or

- b) in accordance with DIN EN 13001-3-1 in conjunction with DIN EN 13001-1 and DIN EN 13001-2 for load combination A (regular loads) using the specific resistance factor for material γ_{sm} as specified in section 5.2.2 of DIN EN 13001-3-1, however, a value of at least 1.0 shall be applied.

Based on the specifications as per b), the risk coefficient γ_n according to DIN EN 13001-2 may be taken as 1.0.

In the case of proof using the global safety factor concept, for structural steel components made of the austenitic steels 1.4541, 1.4306 and 1.4571 according to DIN EN 10088-2 or DIN EN 10088-3 the allowable stresses shall be taken from KTA 3902, Annex D.

5.2.2.3 Fatigue analysis

(1) For the fatigue analysis the following shall be used:

- a) loading level group B 3 in accordance with DIN 15018-1

or

- b) stress history class S3 according to DIN EN 13001-3-1 where a fatigue strength specific resistance factor $\gamma_{mf} = 1.25$ shall be used.

(2) The following shall apply to austenitic steels:

¹ In DIN 15018-1 the term "nominal load spectrum factor" is used instead of "dynamic factor".

a) In the case of proof using the global safety factor concept, the allowable stresses for the fatigue analysis shall be in accordance with KTA 3902 Annex D, section D1, when using austenitic steels 1.4541, 1.4306 and 1.4571 according to DIN EN 10088-2 or DIN EN 10088-3.

b) A design of structural steel components using austenitic steels within the partial safety factors concept is permitted only in those cases where the fatigue analysis may be waived according to section 6.3.3 of DIN EN 13001-3-1, in which case the number of stress cycles shall be determined according to section 5.1.3.

(3) Where the operating conditions are exactly known, e.g. the actually occurring loadings and stress cycles, the fatigue analysis for a single-step or multi-step load collective may be performed

a) in the case of proof using the global safety factor concept, on the basis of a stress-number diagram according to KTA 3902 Annex C for the steels S235 and S355, or on the basis of a stress-number diagram be performed according to KTA 3902 section D 2 for the austenitic steels 1.4541, 1.4306 and 1.4571,

b) in the case of proof using the partial safety factors concept, according to the requirements of DIN EN 13001-3-1 and to the stipulations in 5.2.1.1 and 5.2.1.2.

(4) The following safety shall be ensured:

a) in the case of proof using the global safety factor concept, a safety against the allowable maximum stress of

$$\bar{v} = \sigma_D / \bar{\sigma} \geq 1.12,$$

b) in the case of proof using the partial safety factors concept, a safety against the allowable stress range of

$$v = \frac{\Delta\sigma_{Rd}}{\Delta\sigma_{Sd}} \geq 1.12. \quad (5.2-3)$$

with:

σ_D	endurance limit for normal stresses	N/mm ²
$\bar{\sigma}$	damage-equivalent tensile stress	N/mm ²
$\Delta\sigma_{Rd}$	limit design stress range (normal)	N/mm ²
$\Delta\sigma_{Sd}$	design stress range (normal)	N/mm ²

5.2.3 Increased requirements

5.2.3.1 Dynamic factor

(1) The dead weight of the load shall be multiplied by

a) a dynamic factor of $\psi = 1.45$ in case of redundant load attachment points

or

b) an increased dynamic factor of $\psi = 1.8$ in case of non-redundant load attachment points

for determination of the load assumptions.

Note:

The value $\psi = 1.8$ is obtained from the dynamic factor $\psi = 1.45$ multiplied with a safety factor 1.25 in the case of non-redundant load attachment points ($\psi = 1.45 \cdot 1.25 \approx 1.80$).

(2) Where the maximum hoist speed $v_{h,max}$ is known, instead of the dynamic factor as per sub-clause (1) above the following values may be used

a) the dynamic factor resulting from lifting class H4 according to DIN 15018-1 when using the global safety factor concept,

b) the dynamic factor

$$\Phi_2 = 1.4 + 0.528 \cdot v_{h,max} \quad (5.2-4)$$

for the verification according to DIN 13001-2 when using the partial safety factors concept.

For $v_{h,max}$ the maximum hoisting speed in m/s decisive for the specific load case shall be taken.

In the case of non-redundant load attachment points 1.25 times the dynamic factor shall be used in the calculation.

(3) Where a dynamic factor less than that of sub-clauses (1) or (2) is to be used, the maximum dynamic load factor occurring at the load attachment point during one working cycle shall be determined by means of calculation or experimentally in each individual case. As regards the determination of the dynamic factor this dynamic load factor shall be multiplied

a) in case of redundant load attachment points by a safety factor of 1.25

and

b) in case of non-redundant load attachment points by a safety factor of 1.25 and an additional safety factor of 1.25.

(4) The loads resulting from shifting of the load due to failure of a part of the hoist in accordance with section B 2.1.1.2 of KTA 3902 shall be taken into account if more unfavourable stresses result than those determined with the dynamic factors specified above. For this load case

a) it is permissible to use 1.1 times the stresses of the "main and additional forces" load case (HZ) in accordance with DIN 15018-1 in the case of proof using the global safety factor concept,

b) the loads shall be assigned to load combination C according to section 4.2.4.10 of DIN EN 13001-2 in the case of proof using the partial safety factors concept.

5.2.3.2 Stress analysis

The stress analysis shall be carried out

a) as general stress analysis in accordance with DIN 15018-1 for the "main forces" load case H

or

b) in accordance with DIN EN 13001-3-1 in conjunction with DIN EN 13001-1 and DIN EN 13001-2 for load combination A (regular loads) using the specific resistance factor for material γ_{sm} as specified in section 5.2.2 of DIN EN 13001-3-1, however, a value of at least 1.0 shall be applied.

Based on the specifications as per b), the risk coefficient γ_n according to DIN EN 13001-2 may be taken as 1.0.

In the case of proof using the global safety factor concept, for structural steel components made of the austenitic steels 1.4541, 1.4306 and 1.4571 according to DIN EN 10088-2 or DIN EN 10088-3 the allowable stresses shall be taken from KTA 3902, Annex D, section D1.

5.2.3.3 Fatigue analysis

(1) For the fatigue analysis the following shall be used:

a) loading level group B 4 in accordance with DIN 15018-1

or

b) stress history class S4 according to DIN EN 13001-3-1 where a fatigue strength specific resistance factor $\gamma_{mf} = 1.25$ shall be used.

(2) The following shall apply to austenitic steels:

a) In the case of proof using the global safety factor concept, the allowable stresses for the fatigue analysis shall be in accordance with KTA 3902 Annex D, section D2, when using austenitic steels 1.4541, 1.4306 and 1.4571 according to DIN EN 10088-2 or DIN EN 10088-3.

b) A design of structural steel components using austenitic steels within the partial safety factors concept is permitted only in those cases where the fatigue analysis may be waived according to section 6.3.3 of DIN EN 13001-3-1, in which case the number of stress cycles shall be determined according to section 5.1.3.

(3) The requirements of sub-clauses 5.2.2.3 (3) and (4) shall be met in which case the following safety shall be ensured:

a) in the case of proof using the global safety factor concept, a safety against the allowable maximum stress of

$$\bar{v} = \sigma_D / \bar{\sigma} \geq 1.25 \quad (5.2-5)$$

b) in the case of proof using the partial safety factors concept, a safety against the allowable stress range of

$$v = \frac{\Delta\sigma_{Rd}}{\Delta\sigma_{Sd}} \geq 1.25 \quad (5.2-6)$$

with:

σ_D	endurance limit for normal stresses	N/mm ²
$\bar{\sigma}$	damage-equivalent tensile stress	N/mm ²
$\Delta\sigma_{Rd}$	limit design stress range (normal)	N/mm ²
$\Delta\sigma_{Sd}$	design stress range (normal)	N/mm ²

5.3 Trunnions, bolts, tie rods and similar parts

5.3.1 Additional requirements

5.3.1.1 Dynamic factor

(1) The dead weight of the load shall be multiplied by a dynamic factor of $\psi = 1.35$ for determination of the design loads.

(2) Where the maximum hoist speed is known, the dynamic factor resulting from lifting class H3 according to DIN 15018-1 may be used instead of the dynamic factor as per sub-clause (1) above.

(3) Where a dynamic factor less than that of sub-clauses (1) or (2) is to be used, the maximum dynamic load factor occurring at the load attachment point during one working cycle shall be determined by way of calculation or experimentally in each individual case. As regards the determination of the dynamic factor this dynamic load factor shall be multiplied by a safety factor of 1.12.

5.3.1.2 Stress analysis

(1) The following safety factors shall be proved for the parts

$$v_\sigma = \frac{R_{eH} \text{ or } R_{p0.2}}{\sigma} \geq 1.5 \quad (5.3-1)$$

$$v_\tau = \frac{\tau_{st}}{\tau} \geq 1.5 \quad (5.3-2)$$

$$v_{\sigma_v} = \frac{R_{eH} \text{ or } R_{p0.2}}{\sigma_v} \geq 1.5 \quad (5.3-3)$$

$$\sigma_v = \sqrt{\sigma^2 + 3 \cdot \tau^2} \quad (5.3-4)$$

where

σ	normal stress from the maximum load occurring
σ_v	stress intensity
$R_{eH} \text{ or } R_{p0.2}$	yield point or proof stress
τ	shear stress
τ_{st}	yield point for torsional stress $< R_{eH} / \sqrt{3} \text{ or } R_{p0.2} / \sqrt{3}$

(2) The weld seams shall be dimensioned in accordance with DIN 15018-1 for the "main forces" load case (H).

5.3.1.3 Fatigue analysis

(1) In the case of $N_\sigma < N_D$ the safety for the finite-life fatigue range shall be proved as follows:

$$v_\sigma = \frac{\bar{\sigma}_D}{\sigma} \geq 2.0 \quad (5.3-5)$$

$$v_\tau = \frac{\bar{\tau}_D}{\tau} \geq 2.0 \quad (5.3-6)$$

and

$$\left(\frac{\sigma}{\bar{\sigma}_D} \right)^2 + \left(\frac{\tau}{\bar{\tau}_D} \right)^2 \leq \left(\frac{1.0}{2.0} \right)^2 \quad (5.3-7)$$

(2) The safety for the endurance strength range $N_\sigma \geq N_D$ shall be proved as follows:

$$v_\sigma = \frac{\sigma_D}{\sigma} \geq 2.0 \quad (5.3-8)$$

$$v_\tau = \frac{\tau_D}{\tau} \geq 2.0 \quad (5.3-9)$$

and

$$\left(\frac{\sigma}{\sigma_D} \right)^2 + \left(\frac{\tau}{\tau_D} \right)^2 \leq \left(\frac{1.0}{2.0} \right)^2 \quad (5.3-10)$$

where

$\sigma_D = f(\sigma_n, K_n)$	endurance strength for normal stresses
σ_n	endurance strength of the material test specimen for normal stresses at a 50 % survival probability
K_n	product of endurance strength reduction factor, roughness factor and shape factor for normal stresses
N_D	$5 \cdot 10^6$ stress cycles
N_σ	number of actual stress cycles
R_m	tensile strength
$\bar{\sigma}_D$	finite-life fatigue strength for normal stresses
$\tau_D = f(\tau_t, \tau_{K_t})$	endurance strength for torsional stresses
τ_t	endurance strength of the material test specimen for torsional stresses at a 50 % survival probability
$\bar{\tau}_D$	finite-life fatigue strength for shear stresses
τ_{K_t}	product of fatigue strength reduction factor, roughness factor and shape factor for torsional stresses

(3) The stress-number diagrams shall be determined using the requirements for shafts, axles and similar parts laid down in clause B 1.2.2.1 of KTA 3902.

(4) Material characteristics, fatigue strength reduction factor, roughness factor, stress concentration factor and shape factor shall be taken from the relevant literature, e.g. [1] to [7] (see **Annex E**).

(5) If materials not dealt with in the literature in **Annex E** are used, the above-mentioned characteristic values shall be verified and guaranteed in each individual case.

(6) The requirements of DIN 15018-1 loading level group B 3 shall apply for dimensioning the weld seams.

5.3.2 Increased requirements

5.3.2.1 Dynamic factor

(1) The dead weight of the load shall be multiplied by

a) a dynamic factor of $\psi = 1.45$ in case of redundant load attachment points

or

- b) an increased dynamic factor of $\psi = 1.8$ in case of non-redundant load attachment points.

for determination of the load assumptions.

Note:

The value $\psi = 1.8$ is obtained from the dynamic factor $\psi = 1.45$ multiplied with a safety factor 1.25 in the case of non-redundant load attachment points ($\psi = 1.45 \cdot 1.25 \approx 1.80$).

- (2) Where the maximum hoist speed is known, the dynamic factor resulting from lifting class H4 according to DIN 15018-1 may be used instead of the dynamic factor as per sub-clause (1) above. In the case of non-redundant load attachment points 1.25 times the dynamic factor shall be used in the calculation.

- (3) Where a dynamic factor less than that of sub-clauses (1) or (2) is to be used, the maximum dynamic load factor occurring at the load attachment point during one working cycle shall be determined by way of calculation or experimentally in each individual case. As regards the determination of the dynamic factor this dynamic load factor shall be multiplied

- a) in case of redundant load attachment points by a safety factor of 1.25

and

- b) in case of non-redundant load attachment points by a safety factor of 1.25 and an additional safety factor of 1.25.

- (4) The loads resulting from shifting of the load due to failure of a part of the hoist in accordance with section B 2.1.1.2 of KTA 3902 shall be taken into account if more unfavourable stresses result than those determined with dynamic factors specified above. A stress analysis shall be performed for this load case, where a safety factor equal to or greater than 1.25 against the yield point shall be taken into account. For weld seams it is permissible to use 1.1 times the stresses of the "main and additional forces" load case (HZ) in accordance with DIN 15018-1.

5.3.2.2 Stress analysis

- (1) The safety factors in accordance with section 5.3.1.2 shall be proved for the parts.

- (2) Weld seams shall be dimensioned in accordance with DIN 15018-1 for the "main forces" load case (H).

5.3.2.3 Fatigue analysis

- (1) In the case of $N_\sigma < N_D$ the safety for the finite-life fatigue range shall be proved as follows:

$$v_\sigma = \frac{\bar{\sigma}_D}{\sigma} \geq 2.5 \quad (5.3-11)$$

$$v_\tau = \frac{\bar{\tau}_D}{\tau} \geq 2.5 \quad (5.3-12)$$

and

$$\left(\frac{\sigma}{\bar{\sigma}_D}\right)^2 + \left(\frac{\tau}{\bar{\tau}_D}\right)^2 \leq \left(\frac{1.0}{2.5}\right)^2 \quad (5.3-13)$$

- (2) The safety for the endurance strength range $N_\sigma \geq N_D$ shall be proved as follows:

$$v_\sigma = \frac{\sigma_D}{\sigma} \geq 2.5 \quad (5.3-14)$$

$$v_\tau = \frac{\tau_D}{\tau} \geq 2.5 \quad (5.3-15)$$

and

$$\left(\frac{\sigma}{\sigma_D}\right)^2 + \left(\frac{\tau}{\tau_D}\right)^2 \leq \left(\frac{1.0}{2.5}\right)^2 \quad (5.3-16)$$

- (3) The stress-number diagrams shall be determined using the requirements for shafts, axles and similar parts laid down in clause B 1.2.2.1 of KTA 3902.

- (4) Material characteristics, fatigue strength reduction factor, roughness factor, stress concentration factor and shape factor shall be taken from relevant literature, e.g. [1] to [7] (see **Annex E**).

- (5) If materials not dealt with in the literature in **Annex E** are used, the above-mentioned characteristic values shall be verified and guaranteed in each individual case.

- (6) The requirements of DIN 15018-1 loading level group B 4 shall apply for dimensioning the weld seams.

5.4 Bolted connections

5.4.1 Additional requirements

5.4.1.1 Dynamic factor

- (1) The dead weight of the load shall be multiplied by a dynamic factor of $\psi = 1.35$ for determination of the load assumptions.

- (2) Where the maximum hoist speed is known, the dynamic factor resulting from lifting class H3 according to DIN 15018-1 may be used instead of the dynamic factor as per sub-clause (1) above.

- (3) Where a dynamic factor less than that of sub-clauses (1) or (2) is to be used, the maximum dynamic load factor occurring at the load attachment point during one working cycle shall be determined by way of calculation or experimentally in each individual case. As regards the determination of the dynamic factor this dynamic load factor shall be multiplied by a safety factor of 1.12.

5.4.1.2 Stress analysis

- (1) VDI 2230 Sheet 1 shall be used for dimensioning bolted connections. The following requirements shall be met:

- a) the usage factor of the yield stress during tightening shall be limited to 0.7,
b) the usage factor of the yield stress due to additional forces from operating conditions shall be limited to 0.1.

- (2) If bolted connections according to DIN EN ISO 898-1 and DIN EN ISO 898-2 or DIN EN ISO 3506-1 and DIN EN ISO 3506-2 subject to additional tensile loading are used, then the determined bolt load shall be increased by a factor of 1.12. These requirements are not imposed, if bolts in accordance with Materials Test Sheet WPB 14 according to **Annex A** are used.

5.4.1.3 Fatigue analysis

- (1) The fatigue analysis shall be performed in accordance with VDI 2230 Sheet 1. A safety factor of at least 2.0 shall be ensured against the endurance strength or the finite-life fatigue strength.

- (2) In case of a multi-step load collective (e.g. due to assembly and disassembly activities), the loading history covered by the stress analysis acc. to (1) shall be modelled as damage-equivalent single-step stress collective. The damage-equivalent stress pertinent to the number of stress cycles N_D shall be determined as follows in the analysis of finally quenched and tempered bolts:

$$\bar{\sigma} = \sigma_1 \cdot \left[\frac{\sum_i N_i \cdot \left(\frac{\sigma_i}{\sigma_1}\right)^c}{N_D} \right]^{\frac{1}{c}} \quad (5.4-1)$$

where the following is to be used:

$$N_D = 2 \cdot 10^6$$

$$c = 3$$



with:

- σ_1 actual stress amplitude of 1st step of load collective step (maximum stress)
- σ_i actual stress amplitude of the respective step of load collective
- N_i actual number of stress cycles of the respective step of load collective

The following shall be verified:

$$v = \frac{\sigma_{ASV}}{\bar{\sigma}} \geq 2.0 \quad (5.4-2)$$

with:

- σ_{ASV} stress amplitude of endurance limit of finally quenched and tempered bolts according to VDI 2230 Sheet 1

Note:

Where in the analysis of final-rolled bolts, the stress amplitude of the endurance limit is determined in a suitable manner in due consideration of its dependence on the mean stress, the damaging-equivalent stress may be determined analogously by using σ_{ASG} (stress amplitude of endurance limit of final-rolled bolts in accordance with VDI 2230 Sheet 1) in lieu of σ_{ASV} and $c=6$.

5.4.2 Increased requirements

5.4.2.1 Dynamic factor

- (1) The dead weight of the load shall be multiplied by
 - a) a dynamic factor of $\psi = 1.45$ in case of redundant load attachment points
 - b) an increased dynamic factor of $\psi = 1.8$ in case of non-redundant load attachment points
 for determination of the design loads.

Note:

The value $\psi = 1.8$ is obtained from the dynamic factor $\psi = 1.45$ multiplied with a safety factor 1.25 in the case of non-redundant load attachment points ($\psi = 1.45 \cdot 1.25 \approx 1.80$).

- (2) Where the maximum hoist speed is known, the dynamic factor resulting from lifting class H4 according to DIN 15018-1 may be used instead of the dynamic factor as per sub-clause (1) above. In the case of non-redundant load attachment points 1.25 times the dynamic factor shall be used in the calculation.
- (3) Where a dynamic factor less than that of sub-clauses (1) or (2) is to be used, the maximum dynamic load factor occurring at the load attachment point during one working cycle shall be determined by way of calculation or experimentally in each individual case. As regards the determination of the dynamic factor this dynamic load factor shall be multiplied
 - a) in case of redundant load attachment points by a safety factor of 1.25
 and
 - b) in case of non-redundant load attachment points by a safety factor of 1.25 and an additional safety factor of 1.25.
- (4) The loads resulting from shifting of the load due to failure of a part of the hoist in accordance with section B 2.1.1.2 of KTA 3902 shall be taken into account if more unfavourable stresses result than those determined with dynamic factors specified above. The degree of utilization of the yield stress limit due to additional bolt loads shall be limited to 0.3 for this load case.

5.4.2.2 Stress analysis

- (1) VDI 2230 Sheet 1 together with the conditions specified in clause 5.4.1.2 shall apply to the dimensioning of bolted connections.
- (2) If bolted connections in accordance with DIN EN ISO 898-1 and DIN EN ISO 898-2 or DIN EN ISO 3506-1 and

DIN EN ISO 3506-2 subject to additional tensile loading are used, then the required number of bolts shall be doubled or the determined bolt load shall be increased by a factor of 1.5. These requirements are not imposed, if bolts in accordance with Materials Test Sheet WPB 14 according to **Annex A** are used.

5.4.2.3 Fatigue analysis

- (1) The fatigue analysis shall be performed in accordance with VDI 2230 Sheet 1. A safety factor of at least 2.5 shall be ensured against the endurance strength or the finite-life fatigue strength.
- (2) In the case of a multi-step load collective the analysis as per (1) shall be performed in accordance with clause 5.4.1.3. The following shall be verified:

$$v = \frac{\sigma_{ASV}}{\bar{\sigma}} \geq 2.5 \quad (5.4-3)$$

5.5 Application of loads into structural concrete components

5.5.1 Additional requirements

5.5.1.1 Dynamic factor

- (1) The dead weight of the load shall be multiplied by a dynamic factor of $\psi = 1.35$.
- (2) Where the maximum hoist speed is known, the dynamic factor resulting from lifting class H3 according to DIN 15018-1 may be used instead of the dynamic factor as per sub-clause (1) above.
- (3) Where a dynamic factor less than that of sub-clauses (1) or (2) is to be used, the maximum dynamic load factor occurring at the load attachment point during one working cycle shall be determined by way of calculation or experimentally in each individual case. As regards the determination of the dynamic factor this dynamic load factor shall be multiplied by a safety factor of 1.12.

5.5.1.2 Application of load

- (1) The proof of load application into a structural concrete component shall be performed in accordance with the requirements specified in DIN EN 1992-1-1 in connection with DIN EN 1992-1-1/NA. The loads shall be assumed to be characteristic actions and shall be proved for permanent and temporary design situations.
- (2) DIN EN 1991-1-1 in connection with DIN EN 1991-1-1/NA and DIN EN 1990 in connection with DIN EN 1990/NA shall apply to the determination of load assumptions. In addition to the requirements of these standards, the dynamic factor as per clause 5.5.1.1 shall be considered.
- (3) Construction products or types of construction for which proof of load application is not rendered on the basis of technical building regulations, may be used upon approval by the authorizes inspector according to § 20 Atomic Energy Act if their suitability has been proved as follows:
 - a) by means of an approval under building regulation or
 - b) by means of a European technical approval or
 - c) by other suitable proofs (approval on a case-by-case-basis).
- (4) The additional load on the structural concrete component resulting from the load test specified in no. 3 d) of **Table 9-1** shall individually be taken into account corresponding to the application of the load. In this case, the combination of loads applied shall be assigned to requirement category A2 according to DIN 25449.

5.5.2 Increased requirements

5.5.2.1 Dynamic factor

- (1) The dead weight of the load shall be multiplied by
- a dynamic factor of $\psi = 1.45$ in case of redundant load attachment points
- or
- an increased dynamic factor of $\psi = 1.8$ in case of non-redundant load attachment points.

Note:

The value $\psi = 1.8$ is obtained from the dynamic factor $\psi = 1.45$ multiplied with a safety factor 1.25 in the case of non-redundant load attachment points ($\psi = 1.45 \cdot 1.25 \approx 1.80$).

(2) Where the maximum hoist speed is known, the dynamic factor resulting from lifting class H4 according to DIN 15018-1 may be used instead of the dynamic factor as per sub-clause (1) above. In the case of non-redundant load attachment points 1.25 times the dynamic factor shall be used in the calculation.

(3) Where a dynamic factor less than that of sub-clauses (1) or (2) is to be used, the maximum dynamic load factor occurring at the load attachment point during one working cycle shall be determined by way of calculation or experimentally in each individual case. As regards the determination of the dynamic factor this dynamic load factor shall be multiplied

- in case of redundant load attachment points by a safety factor of 1.25

and

- in case of non-redundant load attachment points by a safety factor of 1.25 and an additional safety factor of 1.25.

(4) The loads resulting from shifting of the load due to failure of a part of the hoist in accordance with section B 2.1.1.2 of KTA 3902 shall be taken into account if more unfavourable stresses result than those determined with the dynamic factors specified above.

5.5.2.2 Application of load

The requirements of clause 5.5.1.2 shall be met in which case the dynamic factor as per clause 5.5.2.1 shall be considered.

5.6 Ropes and chains

Ropes and chains are not permitted as load attachment points.

5.7 Core components

5.7.1 General

For the determination of the load assumptions the dead weight of the load shall be multiplied by a load intensification factor $f_U = 2.0$. The load intensification factor comprises the dynamic factor and additional forces from frictional contacts.

Note:

As regards the proof for the specific load case "load shifting" see clause 5.7.5.

5.7.2 Stress analysis

(1) For the load attachment points of core components only primary stresses are considered. The following allowable stress intensities shall be complied with:

- allowable primary membrane stress intensity

$$P_{m,zul} = 0.66 \cdot R_{p0.2T} \quad (5.7-1)$$

- allowable primary membrane plus bending stress intensity

$$P_{m+b,zul} = 1.0 \cdot R_{p0.2T} \quad (5.7-2)$$

with

$R_{p0.2T}$: proof stress at handling temperature

Note:

Primary stresses are stresses necessary to satisfy the laws of equilibrium of external forces and moments.

Membrane stresses are defined as the average stress value of the individual stress component over the cross-section under consideration.

Bending stresses are defined as variable linear stresses proportional to their distance from the neutral axis.

(2) The stress intensities shall be derived from the individual stress components in accordance with the theory of von-Mises.

(3) The allowable primary stress intensities for weld seams are derived from the allowable primary stress intensity of the base material multiplied by the weld seam factors v and v_2 for the type of loading and weld quality. The weld seam factors v shall be taken from **Table 5-1**.

For the weld seam factors v_2 to consider the weld quality the following values shall be used:

$$v_2 = 1.0 \quad \text{for proved weld quality} \quad (5.7-3)$$

$$v_2 = 0.5 \quad \text{without proof of weld quality} \quad (5.7-4)$$

Type of seam	Type of loading	Weld seam factor v
Butt weld	Tension	1.0
	Compression	1.0
	Bending	1.0
	Shear	0.8
Fillet weld	Any loading	0.8

Table 5-1: Weld seam factors v to consider the respective type of loading

(4) VDI 2230 Sheet 1 shall be used for dimensioning bolted connections. The following requirements shall be met:

- the degree of utilization of the yield stress limit when tightening shall be limited to 0.7,
- the degree of utilization of the yield stress limit as a result of operational additional bolt forces shall be limited to 0.1.

5.7.3 Experimental analysis

(1) For load attachment points of core components the limits of primary membrane plus bending stress intensity need not be complied with if, by testing on a series-produced part or prototype component, it can be proved that

$$a) L_{max} \leq L_G \quad (5.7-5)$$

and

$$b) L_{max} \leq 0.44 \cdot L_U \quad (5.7-6)$$

where

L_{max} = f_U · dead weight (design load)

f_U = 2.0 (load intensification factor)

L_G = service load (deformations are limited such that detaching or attachment of the load carrying device is still possible)

L_U = rupture load or maximum test load

(2) For all experimental analyses the differences between the conditions on the test parts and the most unfavourable combination of the parts used (e.g. dimensional tolerances, minimum of specified strength values) shall be taken into account. The load introduction during the test shall reflect the true conditions on the part. The consideration of these requirements shall ensure that the loads determined during

- b) At the discontinuity the equivalent stress intensity may exceed the allowable stresses specified in DIN 15018-1 provided both the equilibrium of stresses due to local stress redistributions and the allowable stresses are complied with and the equivalent stress intensity does not exceed the following value:

ba) for load case H $\sigma_v \leq 0.8 \cdot R_{p0.2}$

bb) for load case HZ $\sigma_v \leq 0.9 \cdot R_{p0.2}$

bc) for load case HS $\sigma_v \leq R_{p0.2}$

with $R_{p0.2}$: yield strength

Here, plausibility checks are allowed to demonstrate possible stress redistributions.

- c) The stress limitation for σ_v at the discontinuity need not be satisfied if it can be proved by means of a limit analysis that the allowable lower limit load as per section 7.7.4 of KTA 3201.2 are not exceeded in which case, for the purpose of calculating the lower bound collapse load, the following yield stress values shall be taken

ca) in load case H: $\sigma_F = 1.0 \cdot R_{p0.2}$

cb) in load case HZ: $\sigma_F = 1.10 \cdot R_{p0.2}$

cc) in load case HS: $\sigma_F = 1.20 \cdot R_{p0.2}$

and the specified load shall not exceed 67 % of the lower bound collapse load in accordance with section 7.7.4.1 of KTA 3201.2.

- (8) For the evaluation as per (7) the stress intensity to be taken shall be the maximum of

- the equivalent stress intensity according to the von Mises theory and
- the largest principal stress.

- (9) For the allowable stresses of weld seams DIN 15018-1 shall apply.

5.8.2.2 Fatigue analysis

- (1) The fatigue analysis shall be performed in accordance with sections 5.1 to 5.3 using the safety factors specified there.

(2) The fatigue analysis when using the finite element method differs from the procedures under sections 5.1 to 5.3 only with respect to the determination of the nominal stress. Here, the stress intensity determined during the stress analysis shall be evaluated on the basis of linearized individual stress components.

(3) The fatigue strength reduction factor may also be determined on the basis of a FEM analysis alternatively to the requirements of section 5.3. In this case, the fatigue strength reduction factor is calculated to be conservative and is formed by the quotient of maximum stress intensity (non-linearized) and the stress intensity derived from primary membrane and bending stresses as per subclause (1).

5.8.3 Stress analysis using the partial safety factors concept according to DIN EN 13001-3-1

5.8.3.1 Stress analysis

(1) Stresses shall be determined using the loads, load combinations and partial safety factors according to Table 12a of DIN EN 13001-2 and the requirements specified in sections 5.2 to 5.4 and 5.7.

(2) The stresses so determined shall be classified in dependence of the cause of stress and its effect on the mechanical behaviour of the part as per KTA 3201.2, section 7.7.2 into stress categories, i.e. primary stresses, secondary stresses and peak stresses.

(3) Remote from discontinuities only primary stresses shall be considered (cf. clause 5.8.2.1 (3)).

(4) The equivalent stress intensity shall be derived from the linearised individual stress components.

(5) The location of linearisation outside the area of influence of geometric discontinuities shall be selected such that

- only primary stress components are covered,
- the maximum sum of primary stress components is covered.

(6) The requirements of (5) a) und (5) b) are deemed to have generally been met if

a) linearisation is effected at a distance $\sqrt{R \cdot s}$ to the geometric discontinuity in the case of shell-like parts (e.g. skirts, pipes) where R and s are defined as follows:

R : mean smallest radius of shell

s : smallest wall thickness

b) linearisation is effected at a distance of half the section diameter in the case of round steel sections, at a distance of half the smallest dimension of cross-section in the case of rectangular steel sections, sheets and plates,

c) linearisation is effected at a distance $\sqrt{R \cdot s}$ to the geometric discontinuity in the case of other shapes where R and s are defined as follows:

R : half the smallest dimension of rolled section, half the smallest leg width of angle section, radius of bore.

s : smallest wall thickness

Linearisation may also be effected at other distances, but a suitable analytical proof as regards compliance with the requirements of (5) a) and (5) b) shall be performed.

(7) The following shall apply to the equivalent stress intensity derived from the linearised stress components:

a) Remote from the discontinuity the equivalent stress intensity due to the load combinations in consideration of partial safety factors shall not exceed the limit design stress f_{Rd} according to section 5.2 of DIN EN 13001-3-1.

b) At the discontinuity the equivalent stress intensity due to the load combinations in consideration of partial safety factors may exceed the limit design stress f_{Rd} provided both the equilibrium of stresses due to local stress redistributions and the limit design stress are complied with and the equivalent stress intensity does not exceed the following value:

$$\sigma_v \leq 1.2 \cdot f_{Rd}$$

with f_{Rd} : limit design stress

Here, plausibility checks are allowed to demonstrate possible stress redistributions.

c) The stress limitation for σ_v at the discontinuity need not be satisfied if it can be proved by means of a limit analysis that the allowable lower limit load as per KTA 3201.2, section 7.7.4 (maximum absorbable load when using an ideal-elastic/ideal-plastic material behaviour) complies with the equilibrium conditions and that the limit design stress f_{Rd} is not exceeded.

(8) For the evaluation as per (7) the equivalent stress intensity to be taken shall be the maximum of

- the equivalent stress intensity according to the von Mises theory and
- the largest principal stress.

(9) For the limit design stresses in welded connections section 5.2.5 of DIN EN 13001-3-1 shall apply.

5.8.3.2 Fatigue analysis

(1) The allowable stresses to be used in the fatigue analysis shall be determined to meet the requirements of section 13001-3-1.

(2) The fatigue analysis when using the finite element method differs from the procedures under sections 5.2 to 5.4 and 5.7 only with respect to the determination of the nominal stress. Here, the stress intensity determined during the stress analysis shall be evaluated on the basis of the linearised individual stress components.

(3) The fatigue strength reduction factor may also be determined on the basis of a FEM analysis alternatively to the requirements of section 5.3. In this case, the fatigue strength reduction factor is the quotient of maximum equivalent stress intensity (non-linearised) and the equivalent stress intensity derived from primary membrane and bending stresses as per subclause (1).

6 Materials

6.1 Manufacture

The materials used for load attachment points according to sections 4.2 to 4.4 shall be manufactured to meet the basic requirements specified in section 3 of KTA 1401.

Note:

The qualification of the materials manufacturer is deemed to have been proved e.g. if

- a) the manufacturer is approved according to VdTÜV technical leaflet MB WERK 1253/1,
- b) the product is a regulated construction product or a non-regulated construction product which bears the specimen mark of conformity (U mark of conformity).

6.2 Selection of Materials

6.2.1 General

(1) The selection of materials shall be based, in addition to the strength characteristics (yield point, tensile strength) governing the dimensioning, also on the toughness characteristics (resistance to brittle fracture) and, if necessary, on the suitability for welding, the loading capacity in thickness direction and where required the corrosion resistance.

(2) In the case of bolted connections a suitable combination of materials shall be used. The following shall apply to corrosion protection coatings of ferritic bolts and nuts:

- a) In the case of electroplated corrosion protection coatings only bolts and nuts coated by electroplating shall be used together. In the case of corrosion protection coatings by hot dip galvanizing only complete bolting assemblies (bolts, nuts and washers) of one manufacturer shall be used.
 - b) Hot dip galvanized bolts of property classes 8.8 and 10.9 as well as the associated nuts and washers shall be used only if they were galvanized in the manufacturer's own factory or on the manufacturer's responsibility in an external factory.
 - c) Electro-galvanized bolts and nuts may only be used if
 - ca) the electroplating is performed in accordance with DIN EN ISO 4042 and
 - cb) the risk of hydrogen embrittlement resulting from the manufacturing process is minimized by using the prevention measures according to Tables 3 and 4 of DIN EN ISO 4042, independent of the product standard.
 - d) Other metallic corrosion protection coatings may be used if
 - da) the compatibility with the steel is ensured and
 - db) hydrogen embrittlement is avoided and
 - dc) an adequate behaviour during tightening has been proved.
- (3) Hot dip galvanizing of fasteners shall meet the requirements of DIN EN ISO 10648 and of the guideline "Manufacture of hot dip galvanized bolts" [1].

(4) The filler metals and consumables shall have been approved according to VdTÜV technical leaflet MB SCHW 1153.

6.2.2 Materials in accordance with Annex A

(1) Materials tests required for the usually employed materials are specified in the form of materials test sheets in **Annex A** for the dimensional range as specified in the stated quality standards.

(2) The requirements of sub-clause 6.2.1 (2) shall also apply to bolts listed under material test sheet WPB 14.

(3) Inspection certificates 3.2 according to DIN EN 10204 shall be confirmed or be established by the respective authorized inspector as per clause 2 (2) or by the technical inspecting agency tasked by him.

6.2.3 Other materials

(1) Other materials and dimensional limits than those specified in the materials test sheets under **Annex A** are only permitted if corresponding materials test sheets have been compiled and have been subjected to design approval.

(2) Where materials are used for which no allowable stresses are specified in the generally valid engineering standards, the allowable stresses for the stress analysis and the fatigue analysis shall be derived by theoretical analysis or from realistic experiments.

6.3 Testing of materials

(1) The tests specified in the materials test sheets under **Annex A** shall be conducted and certified in accordance with their classification.

(2) The test results shall meet the specified requirements.

6.4 Materials identification marking

(1) The materials identification marking of the product forms shall be maintained during processing.

(2) The transfer of identification marks on product forms for further processing shall be carried out by the manufacturer's employee authorized to transfer identification marks by stamping in the case of inspection certificate 3.1 according to DIN EN 10204 and by the authorized inspector in the case of inspection certificate 3.2 according to DIN EN 10204.

(3) Where during further processing of product forms no material identification mark can be applied for operational or fabrication-dependent reasons, production-accompanying measures shall be taken to ensure that unambiguous identification and traceability is possible.

7 Design approval

7.1 Required documents

(1) The documents specified below shall be submitted in clear and checkable form for design approval by the authorized inspector.

Note:

In the case of parts to be proved under building legislation, the design approval in accordance with this Safety Standard is conducted as a structural static verification.

In the case of components subject to approval under traffic legislation, the design approval in accordance with this Safety Standard is carried out within the framework of type testing under traffic legislation.

(2) A cover sheet shall list the individual design approval documents in addition to the exact designations of the part,

sub-unit or component to be subjected to design approval. It shall also contain a table on the state of the latest revisions and a list of all KTA Safety Standards and specifications applicable to design, manufacture and testing as well as testing, inspection and work instructions, if necessary.

7.1.1 Load attachment points according to section 4.2 or 4.3

7.1.1.1 Design data sheet

The design data sheet shall contain the following data:

- classification of the load attachment point and - if certification for welding according to DIN EN 1090-2 is applied - execution class of weld seams specified according to DIN EN 1090-2,
- dead weight of the load and specifications regarding the centre of gravity, point of load introduction and direction of forces as well as temperatures, fluids and radiological exposure which may impair the material characteristics,
- loads resulting from shifting of the load due to failure of a part of the hoist in accordance with section B 2.1.1.2 of KTA 3902 in the case of increased requirements.
- in case of bolts which, after disassembly, have to be re-assembled again by design:
Indication of the number of disassembly and re-assembly operations and on intended tests and examinations prior to re-using them (e.g. visual inspection, check of load-bearing bolts and related nut threads by ring and plug gauges).

7.1.1.2 General arrangement drawings, detailed drawings and parts lists with material data

The general arrangement drawings, detailed drawings and parts lists with material data shall contain the following data:

- position and arrangement of the load attachment points,
- description of the delimitation between load attachment point and load,
- dimensions for strength calculation,
- correlation of the individual parts to the materials test sheets,
- type of fasteners, specifications in the case of preloaded bolted connections.

7.1.1.3 Strength calculations

The strength calculations shall contain the following data:

- stress, strength and safety analyses for all parts in the load path up to and including the connection of the load attachment point to the load,
- Indication of model structure and quotation of program description, insofar as the calculations are made using data processing systems,
- stress-strain measurement program if this is planned to supplement the calculations.

7.1.1.4 Materials test sheets

For materials not listed in **Annex A** materials test sheets with the following data shall be established:

- identification number of the materials test sheet,
- product form,
- material designation,
- test requirements for the material with indication of the extent of testing and the certification in accordance with DIN EN 10204,
- identification marking of the material.

7.1.1.5 Welding procedure specification

The welding procedure specification shall contain the following data:

- weld geometry and assignment of welds,
- base metals, weld filler metals and consumables,
- welding procedure and welding certification,
- heat treatment,
- welder's qualification/qualification of operating personnel of fully mechanized and automatic welding units,
- quality level,
- welding data.

Note:

As regards design approval documents required for welding production tests see section 8.1.

7.1.1.6 Test instructions for non-destructive testing

- Test instructions shall be established for non-destructive testing, where required in section 8 or in **Annex B**.
- These instructions may be established for identical test objects in standardized form.
- The test instructions shall contain detailed information on:
 - assignment to the individual test objects,
 - time of testing as far as it influences the extent and performance of the test in accordance with the test and inspection sequence plan,
 - test requirements, test methods and test facilities/equipment to be used, type of sensitivity adjustment for ultrasonic testing,
 - if required, additional explanations regarding the performance of the test (e.g. drawing to scale),
 - reference system and counting direction for a description of indications assigned to a test object,
 - information for recording and evaluating of indications,
 - intended substitute measures to be taken if the applicability of the requirements of **Annex B** is restricted.

7.1.1.7 Test and inspection sequence plan for final inspection

- The test and inspection sequence plan shall contain the following data:
 - requirements and extent of the tests and inspections in accordance with section 8,
 - test and inspection sequence as well as type of tests and inspections and certificates,
 - person performing the test or inspection (manufacturer, authorized inspector).
- As regards the sequence of performance of tests and inspections, the test and inspection sequence plan for final inspection shall be subdivided into test and inspections to be performed prior to, during and upon finalization of production.
- Where required due to the complexity of tests and inspections, the test and inspections listed under **Table 8-1** shall be subdivided into individual test and inspection steps in the test and inspection sequence plan for final inspection.

7.1.1.8 Test and inspection sequence plan for acceptance testing

The test and inspection sequence plan for acceptance testing shall contain the following data:

- requirements and extent of the tests and inspections in accordance with section 9,
- test and inspection sequence.



7.1.1.9 Test and inspection sequence plan for in-service inspections

The test and inspection sequence plan shall contain the following data:

- a) requirements and extent of the tests and inspections in accordance with section 10,
- b) intervals between tests and inspections.

7.1.2 Load attachment points according to section 4.4

7.1.2.1 Drawings, parts lists and specifications

The general arrangement drawings, detailed drawings, parts lists and specifications shall contain the following data:

- a) dimensions for strength calculation of load attachment points,
- b) material data to make assignment of individual parts to the materials test sheets possible,
- c) type of fasteners, specifications in the case of preloaded bolted connections.

7.1.2.2 Strength calculations

The strength calculations shall contain the following data:

- a) position and arrangement of the load attachment points,
- b) description of the delimitation between load attachment point and load,
- c) dead weight of the load and indication of the point of load application and direction of forces as well as temperatures, fluids and radiological exposure which may impair the material characteristics,
- d) stress, strength and safety analyses for the load attachment point,
- e) indication of model structure and quotation of program description, insofar as the calculations are made using data processing systems,
- f) description of the test program and test results in the case of experimental analysis.

7.1.2.3 Materials test sheets

For materials not listed in **Annex A** materials test sheets with the following data shall be established:

- a) identification number of the materials test sheet,
- b) product form,
- c) material designation,
- d) test requirements for the material with indication of the extent of testing and the certification in accordance with DIN EN 10204,
- e) identification marking of the material.

7.1.2.4 Welding procedure documentation

Where a welding procedure is applied during fabrication of the load attachment point, a document shall be established to specify the applied welding procedure qualification requirements. These requirements comprise the establishment of welding procedure specifications, the performance of welding procedure qualifications and the required qualification of welders or welding operators and weld setters.

Note:

As regards design approval documents required for welding production tests see section 8.1.

7.1.2.5 Test and inspection documents

The tests and inspections to be performed by the manufacturer shall be fixed.

7.2 Procedure

(1) The documents submitted in accordance with section 7.1.1 or 7.1.2 shall be checked for:

- a) completeness,
- b) correspondence of the data with the specified values and requirements,
- c) compliance with the licensing provisions and requests of the supervisory authority.

(2) The documents submitted in accordance with sections 7.1.1.1 and 7.1.1.2 shall, additionally, be checked for:

- a) accessibility of the load attachment points for maintenance and repair work and for in-service tests and inspections,
- b) correspondence of the data regarding materials in the parts lists and in the associated materials test sheets.

(3) The documents submitted in accordance with sections 7.1.1.3 and 7.1.2.2 shall, additionally, be checked for:

- a) correctness and completeness of the load assumptions,
- b) correctness and completeness of the calculations,
- c) observance of the allowable stresses or allowable loadings and of the safety factors.

(4) The materials test sheets compiled in accordance with sections 7.1.1.4 and 7.1.2.3 shall be checked for correctness with regard to the extent of testing and type of certification.

(5) The welding procedure specification submitted in accordance with sections 7.1.1.5 and 7.1.2.4 shall be checked with regard to the suitability of the intended welding procedure as well as to the correctness and completeness of the data.

7.3 Certification of design approval

(1) The authorized inspector shall establish a certificate on the performance of the design approval and the results obtained.

(2) In the event of a positive result, the design approval is regarded as concluded upon submission of this certificate.

8 Final inspection

8.1 General

(1) Prior to the beginning of production, the observance of the following requirements regarding manufacture shall be proved:

- a) confirmation of the manufacturer's ability to meet the quality assurance requirements according to KTA 1401,
- b) attestation of welding qualification
 - ba) basically by attestation of qualification according to DIN 18800-7, class E, with extension to the requirements of DIN 15018-2 (the attestation of qualification shall be provided on the basis of welding procedure qualifications according to DIN EN ISO 15614-1),
 - or
 - bb) the manufacturer shall be certified for execution class EXC 4 according to DIN EN 1090-2,
- c) qualification test certificate of welders/operating personnel of fully mechanized and automatic welding units,
- d) certification of supervisory personnel and NDT personnel according to the provisions in section B 2.1,
- e) suitability of production, measuring and test facilities,
- f) validity of marking-transfer certificate,
- g) calibration of welding equipment and heat treatment facilities,
- h) suitability of the devices for measuring the influencing parameters of bolted connections.

(2) Where materials and welding procedures are used which are not part of the welder's qualification in accordance with clause (1) b), welding procedure qualifications according to DIN EN ISO 15614-1 shall be submitted. If no principal rules for the performance of welding procedure qualifications are available for welded joints between certain materials, production tests shall be performed according to design-approved documents within the scope of final inspection.

(3) Deviations from the design-approved documents are only permitted by agreement with the authorized inspector.

8.2 Load attachment points according to section 4.2 or 4.3

8.2.1 General

Within the final inspection the correspondence of the design approval documents with the construction of the load attachment point shall be checked.

8.2.2 Documents

The following documents shall be available:

- a) test and inspection sequence plan for the final inspection in accordance with 7.1.1.7,
- b) detailed drawings and parts lists with data on materials,
- c) materials documentation,
- d) certificate concerning the transfer of markings on product forms in accordance with section 6.4,
- e) welding procedure specifications in accordance with 7.1.1.5,
- f) certificates on the suitability for welding in accordance with 8.1,
- g) test instructions.

8.2.3 Extent of tests and inspections

The extent of tests and inspections prior to the beginning of production is specified in section 8.1, the extent of final inspection on the components shall be taken from **Table 8-1**. The non-destructive tests and inspections shall be conducted in accordance with **Annex B**. The manufacturer shall perform 100 % of the tests and inspections. The tests and inspections to be performed by the authorized inspector are specified for the individual test and inspection steps in **Table 8-1**.

8.2.4 Certification of final inspection

(1) The authorized inspector shall establish a certificate on the performance of the final inspection and the results obtained.

(2) In the event of a positive result, the final inspection is regarded as concluded upon submission of this certificate.

8.3 Load attachment points according to section 4.4

8.3.1 General

Within the final inspection the correspondence of the design approval documents with the construction of the load attachment point shall be checked.

8.3.2 Documents

The following documents shall be available:

- a) drawings, parts lists and specifications,
- b) test and inspection documents in accordance with 7.1.2.5,
- c) materials documentation in accordance with materials test sheets,
- d) welding procedure qualifications according to 7.1.2.4.

8.3.3 Extent of tests and inspections

The type and extent of the tests and inspections to be performed by the manufacturer shall be taken from the related specification. The extent of tests and inspections by the authorized inspector are specified in **Table 8-1**.

8.3.4 Certification of final inspection

(1) The type of certificate of the tests and inspections to be performed by the manufacturer shall be laid down in the specification.

(2) The authorized inspector shall establish a certificate on the performance of the final inspection and the results obtained.

(3) In the event of a positive result, the final inspection is regarded as concluded upon submission of this certificate.

9 Acceptance test

9.1 Load attachment points according to section 4.2 or 4.3

9.1.1 General

Before the load attachment point is put into service an acceptance test shall be conducted by the authorized inspector to prove that the load attachment point in its ready-for-operation condition meets the requirements with regard to load-carrying capacity and functional capability.

9.1.2 Documents

The following documents shall be available for the acceptance test:

- a) test and inspection sequence plan for the acceptance test in accordance with 7.1.1.8,
- b) documentation of the tests and inspections in accordance with sections 7 and 8 with the associated test certificates.

9.1.3 Extent of tests and inspections

(1) The extent the tests and inspections shall be taken from **Table 9-1**.

(2) Tests already conducted and documented within the framework of the final inspection may be dispensed with in the acceptance test.

9.1.4 Certification of acceptance test

(1) The authorized inspector shall establish a certificate on the performance of the acceptance test and the results obtained.

(2) In the event of a positive result, the acceptance test is regarded as concluded upon submission of this certificate.

9.2 Load attachment points according to section 4.4

For load attachment points on core components an acceptance test is not required.

10 In-service inspections

10.1 Load attachment points according to section 4.2 or 4.3

10.1.1 General

(1) Unless otherwise specified, the in-service inspections shall be conducted by the licensee in test intervals as specified in 10.1.3. The inspection dates shall be agreed upon in good time between the licensee and the authorized inspector.