

Safety Standards

of the
Nuclear Safety Standards Commission (KTA)

KTA 3902 (2020-12)

Design of Lifting Equipment in Nuclear Power Plants

(Auslegung von Hebezeugen in Kernkraftwerken)

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

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Design of Lifting Equipment in Nuclear Power Plants

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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) on 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>).

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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, 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 of the Safety Requirements for Nuclear Power Plants, this Safety Standard specifies the design criteria for lifting equipment. Additionally, lifting equipment shall be erected and operated in accordance with the valid federal and state safety regulations as well as with the regulations of the official accident insurance institutions.

(3) Regarding the danger potential, the design shall be based on

- a) additional requirements or
- b) increased requirements

for lifting equipment which exceed the general provisions, as well as

- c) requirements for lifts in reactor containments and
- d) requirements for refuelling machines

as specified in this Safety Standard in detail.

(4) General requirements regarding quality assurance are specified in Safety Standard KTA 1401.

(5) The requirements for inspection, testing and operation, including specific requirements for quality assurance, are laid down in KTA 3903.

1 Scope

This Safety Standard applies to the design of lifts, cranes, winches, trolleys, load carrying devices and refueling machines of light water reactors, collectively called lifting equipment in the following, in as far as they are used in nuclear power plants and meet the special provisions of section 4.

2 Definitions

(1) Parts in the load path

In this Safety Standard, parts shall be deemed to be "within the load path" if they

- a) can directly lead to an inadmissible impairment of the lifting capacity of lifting equipment in case of their failure,

or

- b) are welded on to a part as per a), where only the area of the welded on component, that influences the stress curve within the component according to a), is considered to be within the load path.

(2) Maximum operational load

The maximum operational load is the load which is moved with the lifting equipment during specified normal operation.

(3) Refueling machines for light water reactors

A refueling machine for light water reactors is that equipment which is directly used to charge the reactor core with fuel assemblies or control rods (e.g. shim or shutdown rods), or to discharge these from the core.

(4) Lifting load

The lifting load is the sum of maximum erection load or maximum operational load and the dead weights of the components to take up the load to be handled, e.g. bottom block, lifting beam, and the weight of the supporting means, e.g. of the rope.

(5) Load carrying device

Load carrying devices are supporting means, load suspension devices and lifting accessories. They are defined in DIN 15003.

(6) Load shifting

Load shifting is an event where due to failure of one part within the double drive mechanism chain or due to failure of a redundant part of the rope drive within a drive chain with safety brake an additional load is applied on the lifting equipment.

(7) Machine parts

Machine parts are axles, shafts, bolts, tie rods and similar parts.

(8) Maximum erection load

The maximum erection load is the maximum load which may be moved by the lifting equipment during the erection phase until commencement of licensed nuclear operation.

3 General provisions

(1) Lifting equipment shall be erected in accordance with the valid general safety regulations, especially the federal and state work protection regulations and the regulations of the official accident insurance institutions.

(2) Lifting equipment shall at least comply with the generally accepted engineering standards.

4 Special provisions

4.1 Lifts in reactor containments

Lifts in reactor containments shall, in addition to the general provisions of section 3, comply with the requirements of section 5 if their specified normal use extends to the transportation of persons.

4.2 Cranes, winches, trolleys and load carrying devices with additional requirements

(1) 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 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 shutdown condition or to remove residual heat, and no dangers as per section 4.3 need be expected.

then, in order to provide adequate protection against damage, the cranes, winches, trolleys and load carrying devices shall meet the additional requirements of section 6 exceeding the requirements of the general provisions of section 3.

(2) The classification of lifting equipment with regard to additional requirements shall be specified within the nuclear licensing and supervisory procedure. Examples for this classification and for the procedural steps of classification are given in **Annex A**.

4.3 Cranes, winches, trolleys and load carrying devices with increased requirements

(1) 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 radioactivity where the maximum allowable discharge into the atmosphere may be exceeded 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, in order to provide adequate protection against damage, the cranes, winches, trolleys and load carrying devices shall meet the increased requirements of section 7 exceeding the requirements of the general provisions of section 3.

(2) The classification of lifting equipment with regard to increased requirements shall be specified within the nuclear licensing and supervisory procedure. Examples for this classification and for the procedural steps of classification are given in **Annex A**.

4.4 Refueling machines for light water reactors

Refueling machines for light water reactors shall, in addition to the general provisions of section 3, meet the requirements of section 8.

4.5 External events (EVA)

(1) An analytical proof of the adequate protection of lifting equipment against external events is required provided such requirement also exists for the building.

(2) Exceptions are permitted if it is demonstrated that no effects and damage resulting from the lifting equipment can affect the functional capability of any plant component that is designed against external events.

(3) The adequacy of the protection against external events shall be analytically proven for the lifting equipment without load.

(4) If the lifting equipment is designed for a definite parking position, then the analytical proof is only required for this position.

(5) The general principles of KTA 2201.4 apply to all external events.

4.6 Ambient conditions

(1) Ambient conditions, e.g., pressure, temperature, medium, radiological exposure, shall be considered in the design.

(2) The possibility for decontamination, e.g. of the structures, shall be considered in the structural design.

4.7 Ergonomics requirements

Lifting equipment as per sections 4.2 to 4.4 shall satisfy the design principles of DIN EN 894-1 and DIN EN ISO 12100 leading e.g. to the following requirements:

- a) Load carrying devices and their detachable individual items shall be constructed or identified such that confusion of items is excluded.
- b) The command, control and monitoring devices as well as identification markings, actuating, connecting and safety elements shall be designed such that
 - ba) they are compatible both with the usual expectations and the current practice (conformity of expectation),
 - bb) the operating personnel is able to safely perform and monitor the handling processes at any time.
- c) Signals and indications shall be handled to comply with their safety-relevant priority.
- d) The safe handling as well as safe attachment and detachment of loads shall be supported by technical measures.

Table 4-1 shows typical examples. The technical measures shall be supplemented by administrative measures as regards the organisation of transports as per section 9.2 of KTA 3903.

5 Lifts in reactor containments

5.1 General requirements

Lifts shall meet the requirements of the Directive 2014/33/EU and be provided with a safety level according to DIN EN 81-20.

5.2 Passenger lifts and lifts used for transporting goods and passengers

Passenger lifts and lifts used for transporting goods and passengers shall be

- a) connected to a emergency power supply,
- b) connected to the alarm system of the nuclear power plant,
- c) connected to the intercommunication system such that it is possible to communicate from the cabin with the pertinent permanently manned location,
- d) equipped with a specially marked easy-to-open emergency exit.

5.3 Lift shaft

The lift shaft shall be

- a) equipped with pressure-equalization openings to all rooms accessible from the lift shaft; the lift cage or the pressure-equalization openings shall be designed against raised external pressure such that they can withstand the dangers in accordance with sub-clause 4.3 (1) b),
- b) equipped with devices for an emergency exit from which each lift-shaft door is easily accessible,
- c) equipped with lift-shaft doors which can be easily unlocked from the inside,
- d) designed such that the escape route can be easily recognized, and
- e) equipped with emergency lighting connected to a continuous emergency power supply.

Requirement	Lifting equipment/component	Method (selection)	Items of equipment/auxiliary means (selection)	Design
Specified normal use of lifting equipment	Cranes, refueling machines	Structural design	Lockable control system	
	Lifting beams, hangers, rod assembly (capable of being extended, adapted, assembled), lifting accessories, load attachment points	Visual control	Colour coding of connections	Use clearly discernible colours
			Nameplates, other identification, markings	Plates shall be permanently and easily readable Orientation arrows, KKS ¹⁾ , part number
		Structural design	Unmistakable design	e.g. assigned bajonet joints
Load control, ease of running	Cranes, refueling machines	Visual control of load	Load indication on control desk and large display unit	Consistent indication for at least 2 persons
		By control techniques	Additional variably controllable overload protection during operation	Adaptation of overload protection device to the load
		Visual control of travel way	Use of wireless control Under water: camera, searchlight	Non-glare screen easily readable by at least 2 persons from their work position
Load attachment and detachment to meet the requirements	Cranes, refueling machines, lifting beams, hangers, load attachment points	Visual control	Indication of interlocked condition (by colour, mechanical) Under water: camera, searchlight	Recognizable (even under water), component-specific design Unambiguous indication of interlock condition (even in case of an interlock under water) Non-glare screen easily readable by at least 2 persons from their work position.
		Structural design	Interlocking e.g. provided by: - spring-loaded teeth, - bolt with guiding sleeve and connecting member, - spring-loaded safety retainer,	Interlocking under load always effective Consistent design principle (bolts always guided in same direction)
Maintenance of travel areas	Cranes, refueling machines	By control techniques	Travel limits, operational travel interlocks Electrically: travel limiter	Load-dependent travel limiter with indication of state at control points
Exact positioning, avoidance of erroneous positioning, faulty set down/-loading	Cranes	Visual control	Marking/positioning aids (camera, laser measurement)	Easy insight view and unambiguous
			Indication of position	e.g. x-y coordinates
	Refueling machines	Visual control	Visualisation system	Insight view by 2 persons possible
		By control techniques	Automatic operation	Monitoring via inventory management
Precautions against maloperation	Control desk of lifting equipment	Structural design	Simple actuating elements	Anatomically adapted
			Safety against unintentional operation	e.g. shrouded pushbutton
			Actuating elements conforming to expectancy	e.g. lever activated backwards means lifting, lever activated forward means lowering
			Unambiguous assignment of actuating direction and control state	
			Spatial separation/arrangement of operating elements according to function	
			Fault signal	

¹⁾ Power plant identification system, alternatively also plant identification system (AKZ)

Table 4-1: Examples for ergonomic design of lifting equipment as per sections 4.2 to 4.4 and use of auxiliary means

6 Additional requirements for cranes, winches, trolleys and load carrying devices

6.1 Structures

This section applies to the supporting structures of cranes, trolleys and winches.

6.1.1 Design

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

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 lifting device is allowed only if the parts in question are clearly separated from each other and the transmittal of internal forces within the overall structure can be gathered entirely as well as the load bearing characteristics of the entire structure are ascertained correctly. Where an analytical proof regarding external events is to be carried out, clause 4.5 (5) shall be taken into account.

(3) The following data shall be specified for dimensioning the supporting structures:

- a) erection loads including the corresponding working cycles over the intended deployment duration,
- b) operational loads including the corresponding working cycles over the intended deployment duration,
- c) loads from external events in accordance with section 4.5,
- d) ambient conditions in accordance with section 4.6.

6.1.2 Analytic proof

6.1.2.1 Analytic proof using the global safety factor concept according to DIN 15018-1

(1) The stress analysis shall be performed in accordance with **Annex B**, section B 1.1.1.

(2) The supporting structures shall be classified with respect to

- a) the maximum erection load: lifting class H1 and loading level group B2 in accordance with DIN 15018-1.
- b) the maximum operational load: lifting class H3 and loading level group B3 in accordance with DIN 15018-1.

(3) Where a dynamic factor¹ less than that resulting from (2) is to be used, the maximum dynamic load factor occurring 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.

(4) A verification of service strength need not be carried out if it can be demonstrated that the number of stress cycles is below $2 \cdot 10^4$. The number of stress cycles shall be determined in accordance with **Annex B**, section B 1.2.1.2.

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

- a) Where a verification of service strength is to be carried out as per (4), the stress cycles resulting from disassembly

and re-assembly operations shall be taken into account in the analysis.

- b) Where no verification of service strength is required as per sub-clause (4) and a maximum of 10 disassembly and reassembly operations is carried out, a verification of service strength may be waived.
- c) Where more than 10 disassembly and re-assembly operations are carried out, a verification of service strength shall be carried out independently of the requirements of subcl. (4). In this case, both the stress cycles from operational loadings and from disassembly and re-assembly operations shall be taken into account.

6.1.2.2 Analytical proof using the partial safety factors concept according to the standard series DIN EN 13001

(1) The stress analysis shall be performed in accordance with **Annex B**, section B 1.1.2.

(2) The supporting structures shall be classified with respect to

- a) the maximum erection load: stress history class S1 according to DIN EN 13001-3-1,
- b) the maximum operational load: stress history class S3 according to DIN EN 13001-3-1.

(3) The fatigue analysis need not be carried out if the conditions according to section 6.3.3 of DIN EN 13001-3-1 so permit. The number of stress cycles shall be determined in accordance with **Annex B**, section B 1.2.1.2.

(4) In the case of connections made with preloaded bolts to be re-assembled upon disassembly, the following applies in addition to (3):

- a) Where a fatigue analysis is to be carried out as per (3), 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. (3) and a maximum of 10 disassembly and re-assembly operations is carried out, a fatigue analysis may be waived.
- c) Where more than 10 disassembly and re-assembly operations are carried out, an analysis for cyclic operation shall be carried out independently of the conditions according to section 6.3.3 of DIN EN 13001-3-1. In this case, both the stress cycles from operational loadings and from disassembly and re-assembly operations shall be taken into account.

6.1.3 Design and structural requirements

Notes:

(1) Requirements for the design of supporting structures and structural requirements are also contained in DIN EN 1090-2.

(2) Requirements for the structural design of rails, rail connections, track bedding and rail fasteners are also contained in VDI 3576.

(1) When using the global safety factor concept together with an analytical proof according to DIN 15018-1, the design shall be based on DIN 15018-2.

(2) When using the partial safety factor concept together with an analytical proof according to the standard series DIN EN 13001, the design shall be based on the relevant stipulations of this standard series.

(3) Dynamically loaded weld seams shall meet the requirements of quality level B according to DIN EN ISO 5817 or DIN EN ISO 13919-1. Weld seams primarily subject to static loadings shall satisfy the requirements of quality level C of DIN EN ISO 5817 or DIN EN ISO 13919-1.

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

(4) Hollow spaces in supporting structures of lifting equipment inside the containment shall be equipped with pressure equalization openings for the case of raised external pressure or shall be dimensioned to withstand these pressure conditions.

(5) The preloading of preloaded bolted connections shall be carried out according to the guideline DAST 024 of the German Committee for Steel Construction. The calculated preloading force shall be limited to the nominal minimum preloading force $F_{p,C}^* = 0,7 \cdot f_{yb} \cdot A_s$.

6.2 Hoists

This section applies to drive mechanisms and rope drives.

6.2.1 Drive mechanisms

This section applies to gear boxes, series gear boxes, series electric hoists, couplings and brakes.

6.2.1.1 Design

(1) The following data shall be specified for the design of drive mechanisms:

- erection loads including the pertinent working cycles over the intended deployment duration,
- operational loads including the pertinent working cycles over the intended deployment duration,
- dead load of the load suspension devices and supporting means,
- special loads, e.g. loads from the acceptance test, from in-service inspections, from test runs of the gear box, from actuation of the brakes, including the corresponding working cycles over the intended deployment duration,

Note:

When using systems to ascertain the braking effect without test load for in-service inspection, see also KTA 3903, Annex D, section D 3.1.

- duty cycle of the hoist under erection load, operational load and dead load as well as pertinent average hoisting speed and average travel path,
- ambient conditions in accordance with section 4.6.

(2) The dimensioning of series-produced parts like brakes, brake discs, couplings, shall be based on the design data to be determined in accordance with the corresponding forms of KTA 3903, Annex C.

(3) The roller bearings shall be dimensioned on the basis of the calculation principles of the roller bearing manufacturer. Dynamic loads may be subjected to cubic averaging methods which shall be based on a probability of failure of 3 % to be taken with $a_1 = 0.44$. The maximum test load shall be considered to be the static (continuous) load.

6.2.1.2 Analytic proofs

The analytic proofs shall be performed in accordance with **Annex B**, section B 1.2.

6.2.1.3 Design and structural requirements

6.2.1.3.1 General

(1) Hoists shall be equipped with an overload protection device which shall be adjusted to no more than 1.1 times the maximum operational load. The tolerance of the overload protection response level relating to the maximum operational load shall not exceed $\pm 5 \%$.

(2) Hoists shall be equipped with a meter for counting the running hours or the load collectives. A meter for monitoring

the load collectives is required if the analytic proofs are based on a load collective.

Note:

It is presumed that the parameters counted with the load collective meter are adjusted to or transferrable to the assumptions of the design by analysis.

When using a meter that only counts the running time during which the drive mechanism is in motion, 50 % of the indicated time shall be considered full-load hours. When using a meter for load collectives, all loads greater than 10 % of the maximum operational load shall be recorded.

(3) If the weight of the supporting means amounts to more than 30 % of the maximum operational load, then the entire running time of the drive mechanism shall be recorded.

(4) Grey-cast iron bearing housings are not permitted.

6.2.1.3.2 Gear boxes

(1) Shaft-hub linkages with flat, hollow, sunk, tangent and gib-head keys are not allowed.

(2) Shaft hub connections with press fit assembly are permitted for series-production hoist gear boxes and series-production electric hoists with rope if they are designed and constructed according to the state-of-the-art.

(3) The offset between two fitting keys shall be at least 120° . The value of the bearing length of the key used in the analysis shall not exceed 1.2 times the shaft diameter.

(4) The design and construction of transmission gears shall meet the following requirements:

- When calculating the load bearing capacity in accordance with DIN 3990-11, the limits of application and requirements of this DIN standard shall be taken into account.
- When calculating the load bearing capacity according to the method of Niemann [2] in accordance with **Annex B** the following requirements ba) to bg) shall be taken into account.

ba) The ratio of useable face width to pitch circle diameter, b/d_{w1} shall be smaller than or equal to 1.2 for the case of a rigid pinion shaft supported at both ends.

bb) Longitudinal crowning and profile reduction are permitted provided they stay within the size of tooth deformation.

bc) In case of a floating support of the transmission gears or if the bearings of the gear transmission are located on the supporting structure or if the requirement under ba) cannot be met, the width factor shall be determined by measurement or by a correspondingly accurate numerical analysis.

This numerical analysis shall take into account any deformation and relocation that are essential with regard to load distribution over the gear width. Furthermore, the numerical analysis shall consider any fabrication deviations and corrections with their true sign.

bd) The normal modulus m_n for transmission gears shall normally be equal to or greater than $1/25$ of the useable face width, b . If the bearings of the gear transmission are located on the supporting structure or in the case of a floating support of the pinions, the normal modulus m_n shall be larger than $b/25$.

be) No grinding recess is allowed on the side of the tooth.

bf) In the case of ground teeth, protuberance profiles shall be used or the grinding shall be carried out down to the bottom of the tooth with a rounded-off tool head.

bg) Sufficient lubrication shall be ensured. It shall be ensured that the lubrication has an adequate viscosity at the operating temperature.

(5) Grey-cast iron gear box housings are not allowed except for series-produced electric hoists. The weld seams of welded gear box housings shall satisfy the requirements of quality level C of DIN EN ISO 5817 or DIN EN ISO 13919-1.

(6) The gear box quality shall be chosen such that at zero load the tooth bearing

a) in the case of non-crowned teeth, is at least 60 % of the useable face width in counter direction to the deformation tendency under load

and

b) in the case of longitudinally crowned teeth, is at least 40 % of the useable face width beginning about at the centre of the tooth face and running in counter direction to the deformation tendency under load.

6.2.1.3.3 Brakes

(1) Two brakes (service brake and auxiliary brake) shall be located on the drive side upstream of the output transmission which shall act independently of each other.

(2) The brakes shall satisfy the requirements of DIN 15434-1. The required braking torque of each brake shall be designed for the maximum operational load.

(3) It shall be ensured that upon standstill of the drive mechanisms, the maximum operational load is held alone by the service or the auxiliary brake and that the maximum erection load is held by the service and the auxiliary brake, and in both cases with a 2-fold safety. The brakes shall be capable of withstanding the thermal and dynamic operational conditions.

(4) If the service brake fails, the auxiliary brake shall be capable of safely absorbing the increased energy of the system resulting from the failure condition.

(5) Where the drive is of the non-converter type, the auxiliary brake shall engage during any operational braking after a certain time delay with respect to the service brake. The delay time shall be fixed such that during operational braking at full lowering speed and maximum operational load the auxiliary brake engages at the latest when the lowering speed has reached a residual value of 5 %.

6.2.2 Rope drives

The section applies to ropes, rope sheaves, rope drums, rope end terminations and rope drum hinge connections.

6.2.2.1 Design

(1) The rope drives shall be classified in accordance with DIN 15020-1, in which case the larger of the resulting rope diameters shall be used:

- a) for the maximum erection load at least drive mechanism group 1B_m according to DIN 15020-1. If the ratio of rope minimum breaking strength to static rope traction force is at least 3.5, and if ropes are used whose individual strands have a nominal strength up to 1960 N/mm², the design may be based on drive mechanism group 1E_m.
- b) for the maximum operational load at least drive mechanism group 2_m for dangerous transports.

(2) The dimensioning of rope sheaves and wedge sockets shall be based on the design data to be determined in accordance with the corresponding forms of KTA 3903, Annex C.

(3) The diameter of the rope drums, rope sheaves and compensating pulleys shall be dimensioned at least in accordance with drive mechanism group 2_m according to DIN 15020-1.

(4) The rope end terminations shall be dimensioned in accordance with DIN 15020-1.

(5) The rope drum wall thickness shall be calculated using the maximum prevalent dynamic force S_{max} from the load collective of operational conditions in accordance with **Annex B**, sub-clauses B 1.2.1.1 (2) a) to c). Stress peaks which occur rarely and for only very short periods of time need not be considered since they affect only a fraction of one rope wrap.

(6) Rope drum hinge connections shall be dimensioned on the basis of the load collective of operational conditions in accordance with **Annex B**, sub-clauses B 1.2.1.1 (2) a) to c) and shall be analyzed in accordance with the design principles of the manufacturer.

(7) The rope clips shall be dimensioned in accordance with SEB 666211 Suppl. Sheet 1, taking the structural circumstances into account.

6.2.2.2 Analytical proofs

The analytical proofs shall be performed in accordance with **Annex B**, section B 1.2.4.

6.2.2.3 Design and structural requirements

(1) Grey-cast iron rope sheaves and rope compensating pulleys are only allowed if they are series-produced and are protected against mechanical damage.

(2) The wire rope ends may be fastened as follows:

- a) metal socketing in accordance with DIN EN 13411-4.
- b) ferrules according to DIN EN 13411-3 provided the ropes have steel cores,
- c) asymmetrical wedge sockets with a clamping angle of about 14°, a clamping length equal to 5 times the rope diameter and a bending radius at the rope key equal to 1.5 times the rope diameter. The rope key shall be marked with the rope diameter. The wedge socket shall have a breaking strength of at least 85 % of the minimum breaking strength of the rope.
- d) clamping plates for fastening rope ends on the drum in accordance with section 6.4 of DIN 15020-1.

(3) The number of wraps assumed during design, but at least two safety windings of rope shall remain on the drum when the load hook is in its lowest position.

(4) Rope drums shall be of the single-layer winding type only. The orderly winding of the rope shall be monitored or be ensured by structural design measures (e.g. rope guide rings).

(5) The weld seams of welded rope drums shall satisfy the requirements of quality level B of DIN EN ISO 5817 or DIN EN ISO 13919-1.

6.3 Lateral transport drives

This section applies to the wheel bearings and wheels, wheel axles and shafts.

6.3.1 Design

The following data shall be specified for the dimensioning of lateral transport drives:

- a) running time classification in accordance with Table 5 of the DIN calculation principles for drive mechanisms in lifting equipment [7],
- b) standard load collective in accordance with Table 6 of the DIN calculation principles for drive mechanisms in lifting equipment [7],
- c) running time of the drive motor (in terms of 1 h) in accordance with Table 4 of DIN 15070,
- d) ambient conditions corresponding to section 4.6.

6.3.2 Analytical proofs

The analytical proofs shall be performed in accordance with **Annex B**, section B 1.3.

6.3.3 Design and structural requirements

- (1) Lateral transport drives shall be equipped with wheel-fracture supports.
- (2) DIN 15085 applies to the wheels.

6.4 Load carrying devices

This section applies to supporting means, load suspension devices and lifting accessories.

6.4.1 Supporting means

This section applies to jigs and fixtures permanently connected to the lifting equipment for the purpose of attaching load suspension devices, lifting accessories, or loads (e.g. load hooks, load hook mountings, grabs, lifting beams, hangers) as well as top and bottom blocks and the mountings for compensation pulleys and rope end terminations.

6.4.1.1 Design

- (1) The load hooks shall be classified in accordance with DIN 15400 as follows:
 - a) for the maximum erection load at least classified in drive mechanism group 1B_m,
 - b) for the maximum operational load at least classified in drive mechanism group 2_m.
- (2) Stainless steel load hooks shall be classified with additional consideration given to the material characteristics.
- (3) The design of supporting means as supporting structures shall be in accordance with the requirements of section 6.1.1 and the design of supporting means as machine parts in accordance with section 6.2.1.1.
- (4) 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 tensional loading are used, then the determined bolt load shall be increased by a factor of 1.12 both in the stress analysis and the fatigue analysis. These requirements need not be met if bolts acc. to KTA 3903, Annex A, materials test sheet WPB 3.17 are used.

6.4.1.2 Analytical proofs

- (1) The analytical proofs shall be performed in accordance with **Annex B**, section B 1.4.
- (2) 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 non-rotating mechanical parts and other parts, 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 load-bearing elements made of welded or screwed together steel plates or rolled steel sections.
- (2) Other parts refer, inter alia, to parts where a stress evaluation on the basis of nominal stresses is not purposeful.

This requirement shall likewise apply if austenitic steels are used.

- (3) In addition to (2) the requirements of clause 6.1.2.1 (5) apply in case of joints with preloaded bolts which, after disassembly, have to be re-assembled again.

6.4.1.3 Design and structural requirements

- (1) The load shall be attached in a positive-locking way only. Structural safeguarding measures shall be taken against unintentional detachment of the load. The connections and individual items shall be designed such that they cannot be detached unintentionally. The safeguarding devices shall be designed and arranged so that such unintentional changes of their positions are excluded where their safety functions are ensured only to a limited extent or are completely cancelled.
- (2) For the protection against damage the following requirements shall be met:
 - a) Hydraulic, pneumatic and electric lines shall be laid such that damage due to operational equipment movement is avoided.
 - b) where the lifting capacity can be adversely affected by wear, corrosion or other damaging influences it shall be ensured that the respective condition can be checked.
 - c) Firmly sheathed individual parts shall be protected against corrosion.
 - d) Movable sheathing shall be designed or arranged such that it is possible to uncover parts requiring an examination.

6.4.2 Load suspension devices

This section applies to jigs and fixtures not belonging to the lifting equipment, which can be connected to the supporting means of the lifting equipment for the purpose of attaching the load, e.g. load hooks, load hook mountings, lifting beams, hangers and grabs.

6.4.2.1 Design

- (1) The design of load suspension devices as supporting structures shall be in accordance with the requirements of section 6.1.1 and the design of load suspension devices as machine parts in accordance with section 6.2.1.1.
- (2) Section 6.4.1.1 applies to load hooks.
- (3) The working load limit of
 - a) rope slings acc. to DIN EN 13414-1 and DIN EN 13414-2,
 - b) chain slings according to DIN EN 818-4,
 - c) components for lifting accessories according to DIN EN 1677-1, DIN EN 1677-2, DIN EN 1677-3, and DIN EN 1677-4,
 - d) shackles according to DIN EN 13889

respectively, as a fixed component part of load suspension devices may be utilized to reach not more than 50 % of the values specified in these standards. A dynamic factor need not be taken into account.

- (4) 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 tensional loading are used, then the determined bolt load shall be increased by a factor of 1.12 both in the stress analysis and the fatigue analysis. These requirements need not be met, if bolts acc. to KTA 3903, Annex A, materials test sheet WPB 3.17 are used.

6.4.2.2 Analytical proofs

The requirements of section 6.4.1.2 shall be met.

6.4.2.3 Design and structural requirements

- (1) The requirements of section 6.4.1.3 shall be met.
- (2) The use of rope slings and chain slings as fixed component parts of load suspension devices is permitted provided they meet the requirements of DIN EN 13414-1 and DIN EN 13414-2 as well as DIN EN 818-4, respectively, and if both are designed without sheaving and with defined load transmission points.
- (3) Fibre ropes and woven bands are not permitted.
- (4) Only chains according to DIN EN 818-2 and with an inside width $b_1 = 1.3 \cdot d$ are permitted.
- (5) DIN EN 1677-1, DIN EN 1677-2, DIN EN 1677-3, and DIN EN 1677-4 shall apply to the components of lifting accessories.
- (6) Chain attachment elements and connection parts shall be designed to be irremovable from the hanger and end links.
- (7) The elements connecting the rope slings and chain slings to the load attachment points shall be designed to be unambiguously identifiable, where confusion of elements may lead to an unacceptable condition.
- (8) Any surface treatment procedure used on chain slings shall be such that no damage occurs to the base material (e.g. hydrogen inclusion).

6.4.3 Lifting accessories

6.4.3.1 General

- (1) This section applies to rope slings and chain slings.
- (2) Lifting accessories shall be clearly assigned to fixed transport operations and shall only be used for operations they are assigned to.

6.4.3.2 Design

The working load limit of

- a) rope slings acc. to DIN EN 13414-1 and DIN EN 13414-2,
 - b) chain slings according to DIN EN 818-4,
 - c) components for lifting accessories according to DIN EN 1677-1, DIN EN 1677-2, DIN EN 1677-3, and DIN EN 1677-4,
 - d) shackles according to DIN EN 13889
- may be utilized to reach not more than 50 % of the values specified in these standards. A dynamic factor need not be taken into account.

6.4.3.3 Design and structural requirements

- (1) Only rope slings according to DIN EN 13414-1 and DIN EN 13414-2 and chain slings that meet the requirements of DIN EN 818-4 as well as components for lifting accessories according to DIN EN 1677-1, DIN EN 1677-2, DIN EN 1677-3, and DIN EN 1677-4 are permitted.
- (2) Rope slings and chain slings are permitted only if both are designed without sheaving and with defined load transmission points.
- (3) The requirements specified in section 6.4.1.3 shall be met.
- (4) The requirements specified in para 6.4.2.3 (3) through (8) shall be taken into account.

6.5 Electrical equipment

6.5.1 General

- (1) Safety functions shall be provided which, in case of inadmissible operating conditions or inadmissible excess of

limitations (travel, speed and loads, or a combination thereof), shall effect shutdown of the pertinent drives and prevent drives from starting up. The shutdown of a drive shall include the release of the required brakes.

- (2) The control system shall be subdivided into an operational control system and a safety-related control system. The latter shall be independent of the operational control such that in case of specified normal operation, malfunction or failure of the operational control system, the function of the safety-related control system remains effective. In such case, the following shall be satisfied:

- a) Functions required for lifting equipment operation, which do not monitor the occurrence of inadmissible operating conditions or inadmissible excess of limitations e.g. travelling control command shall be part of the operational control system.
- b) The safety-related control system shall monitor the observance of all safety-relevant limit values of lifting equipment and, in the case of inadmissible operating conditions or inadmissible excess of limitations, shall transfer the lifting equipment to safe condition. Functions classified into Performance Levels c, d and e according to **Annex E**, shall be part of the safety-related control system.
- c) Whenever software-based safety-related control systems are employed, only software shall be used, that has been developed and established satisfying the requirements for the software of class 2 I&C systems acc. to DIN EN IEC 62138, section 6.

- (3) When realizing the functions required for safe operation of lifting equipment the requirements of DIN EN ISO 13849-1 shall basically be met, in which case the Performance Levels shall be determined to **Annex E**, section E 2. **Table E-1** assigns Performance Levels to the respective typical functions. Deviations from the Performance Level laid down in **Table E-1** shall be justified in each individual case.

Note:

The requirements of DIN EN ISO 13849-1 include that the failure behavior of mechanical components used for connection and actuation of sensors involved in the execution of safety functions shall be taken into account.

In lieu of the Performance Levels laid down in **Table E-1** according to DIN EN ISO 13849-1, the Safety Integrity Levels (SIL) defined in the standard series DIN EN 61508 may be used, in which case the requirements as per SIL 2 according to DIN EN 61508 are deemed to be equivalent to the requirements as per Performance Level "d" according to DIN EN ISO 13849-1 and the requirements as per SIL 3 are deemed to be equivalent to the requirements as per Performance Level "e".

- (4) Safety-related functions of Performance Level "c" to "e" according to DIN EN ISO 13849-1 shall be effective independently of the operational control functions. Faults in operational control functions shall not render these safety-related functions ineffective. Safety-related functions of Performance Level "d" shall be effective at least in category 3 and safety-related functions of Performance Level "e" in category 4 according to DIN EN ISO 13849-1. The reaction times of all safety-related functions shall be sufficiently short to fulfil the respective safety task.

- (5) When planning, designing and executing the safety-related functions of Performance Levels "c" to "e" according to DIN EN ISO 13849-1 the requirements contained in DIN IEC 61513 for functions of category B shall be met.

- (6) For all limiting and interlocking functions required by this Safety Standard positively opening control switches operating to the closed-circuit current principle or another technique shall be used to obtain equivalent safety like in the case of positively opening control switches.

(7) Closed working cabins and operating cabins in cranes inside the controlled area shall be connected to the alarm system and the safety illumination system of the nuclear power plant such that alarms are perceived and escape routes are discernible.

(8) Measures shall be taken to make possible the unambiguous identification of the current version of hardware and software utilized for functions classified into Performance Levels c, d and e according to **Annex E**.

(9) Measures shall be taken to ensure that the in-service functional tests in accordance with KTA 3903 can be performed without manipulation of the electrical equipment (e.g. loosening of wire connections, removal of equipment parts). In this case, it shall be ensured that the entire signal path can be covered by the in-service functional tests.

Testing equipment shall be provided with an access-enable program so that it can be activated by authorized personnel only.

Where testing equipment not provided with automatic return is used, its activation shall be annunciated by a signal. Deactivated testing equipment shall not have any influence on the safety-related functions of Performance Levels "c" through "e" according to DIN EN ISO 13849-1 even in the case of fault.

For the in-service tests of safety travel limiters of hoists and lateral transport drives a release device shall be provided which, when activated, makes it possible for the crane operator, upon release of the travel limiter, to leave the travel way in opposite direction of movement at creep speed. The release device for leaving the safety travel limiter shall be of the locking-type and be provided with automatic return (e.g. key-operated pushbutton) and be positioned such that a second person (within the sense of the 4-eyes principle) can be employed to operate the release device.

6.5.2 Requirements for the electrical equipment

(1) It shall be possible to activate the crane switch only if it has been released by means of a key-operated switch or a similarly safeguarded switching device.

(2) The three-phase current supply shall be equipped with a phase-sequence relays and a phase conductor monitor. Where these monitoring devices respond, it shall not be possible to switch in the crane switch, and where the lifting equipment is operating, the crane switch shall switch off. The response of these monitoring devices shall initiate an alarm signal at the control points.

(3) The response of overcurrent protective devices shall switch off only the pertinent motor branch circuit, unless several motors are available for the same function which must be switched off simultaneously. The coils of hoist motors shall be equipped with sensors for monitoring the temperature. The response of overcurrent protective devices shall trigger an alarm signal at the control points.

(4) The actuation of the overload protection shall interrupt the hoist movement and trigger an alarm signal at the control points. Upon acknowledgement of the alarm signal lowering shall be possible.

The overload protection shall be set at no more than 1.1 times the maximum operational load.

The response tolerance of the overload protection relating to the maximum operational load shall not exceed $\pm 5\%$.

For the putting of lifting equipment into operation the switching threshold shall be adapted to the swinging behaviour when lifting the load.

(5) The hoists shall be equipped with a meter for monitoring the running time or the load collective in accordance with section 6.2.1.3.1. Measures shall be taken to prevent data

loss (e.g. by redundant data storage, storage on fail-safe medium or regular data saving).

(6) It must be possible to actuate the hoist brakes individually and independently of each other; the brakes shall be connected to all phases. In the case of non-converter operated drives, the auxiliary brake in accordance with para. 6.2.1.3.3 (5) shall engage after a certain time delay after the service brake.

A warning shall be triggered at the control points if the brake lining thickness of the service brake is less than the minimum thickness and if the service or the auxiliary brake do not open or close (activity of the brake bleeding device). In case of electromagnetic compact brakes it is permitted to derive the indication that the brake does not open or close from one switch only. Sliding rotor motors with integrated brakes are exempted from the requirement regarding a non-opening or non-closing alarm.

Note:

When using systems to ascertain the braking effect without test load for in-service inspection, see also KTA 3903, Annex D, section D 3.1.

(7) If non-converter drives are used, the lateral transport drives and hoists shall have at least one creep speed aside from the nominal speed. Accelerations and decelerations shall be kept low when changing speed.

(8) In the case of converter drives, monitoring shall be required such that the lifting equipment is stopped at zero position of the control system and maintained at standstill and that, at activation of the control system, movement is in the right direction.

(9) In the case of electrically driven load suspension devices respective position indications shall be provided at the control points (e.g. grab opened, grab closed).

(10) It shall be ensured by means of electrical interlock that the control command for detachment of an attached load (e.g. control signal "Open grab" cannot be released unintentionally or at positions which are not permitted as regards safety.

(11) Where the orderly winding up of the rope on the drum cannot be ensured by structural measures, monitoring is required. Where monitoring shows an inadmissible deviation, a standstill shall be effected and an alarm signal be released at the control points.

6.5.3 Limiting functions

(1) To limit the crane and trolley movement as well as the lifting and lowering movement, operational travel limiters in accordance with **Table E-1** shall be provided. Additional safety travel limiters shall be provided in accordance with **Table E-1**.

- a) for lateral transport drives where no mechanical travel way end limiters are provided,
- b) for hoists at the top and bottom end of hoist travel way.

(2) Where electronic travel way measuring systems are used for safety-related functions of Performance Levels "c" through "e" according to DIN EN ISO 13849-1,

- a) the adjustment function (preset) of these systems shall be released by technical measures (e.g. key-operated switches),
- b) redundant travel way measuring systems shall basically be designed and arranged such that a simultaneous mechanically caused failure of the transmitters is excluded,
- c) a monitoring device for the detection of a sensor failure due to mechanical reasons is required in the case of redundant travel way measuring systems that cannot meet the requirement according to b) and in the case of non-redundant travel way measuring systems,
- d) a slip-free drive is required if absolute value encoders are used.

(3) Where the operational travel limiter responds, its slowing-down path shall be dimensioned such that drive standstill is effected prior to reaching the safety travel limiter position. Upon response of the operational travel limiter, movement in the respective opposite direction shall be possible.

(4) As long as the safety travel limiter is actuated, no movement of the lateral transport drive or hoist shall be possible. For in-service inspections measures shall be taken to make movement in opposite direction possible upon running into the safety travel limiter. The response of the safety travel limiter shall trigger an alarm signal at the control points.

(5) It shall be ensured by technical measures that mechanical travel limiters and safety travel limiters can only be approached with the allowable speed. Measures to limit and monitor the allowable speed at the lateral transport drive and hoist end positions are not required if

- a) for lateral transport drives
 - aa) the mechanical travel way end limiter is designed for the nominal speed
 - or
 - ab) the slowing-down path provided for at response of the safety travel limiter is dimensioned such that the mechanical travel limiter is not approached or only at the allowable speed,
- b) for hoists the slowing-down path provided for at response of the safety travel limiter is adequately dimensioned.

(6) If, for safety reasons, the lifting and lateral movements need be partially or entirely restricted (e.g. movements above the fuel pool), this shall be ensured by a respective interlock function. The activation of the interlock shall trigger an alarm at the control points.

6.5.4 Control and alarm systems

6.5.4.1 Control system

(1) An interlock shall be provided to ensure that no drives are started up when activating lifting equipment (even in the case of an activated control device).

(2) In the case of drives with specific speed levels, the speed controls for the hoists and lateral transport drives shall be designed such that the maximum speed can only be set by passing through the individual speed levels starting at zero. The individual speed levels shall be displayed at the controls.

(3) The controls shall be designed not to be self-locking. Mechanical controls shall be designed to self-reset into normal position. This is not required if a release switch in the control mechanism initiates the resetting procedure electronically.

(4) At the controls, the direction of movement shall be clearly discernible and identical to the markings on the lifting equipment or building.

(5) All control points shall be equipped with an "emergency-off" switch for all-pole disconnection which turns off all drives. This switch shall remain operative even at inactivated control points. The emergency-off function shall be designed according to DIN EN 60204-32 in stop category "0" or stop category "1". Where stop category "1" is used, the delayed safe shut-off (less than 0.5 seconds) shall be initiated independently of the drive standstill reached.

(6) For transport operations according to KTA 3903, subclause 9.2 (10) a switch-off device, e.g. an additional "emergency-off switch" shall be provided for all-pole disconnection of drives by the supervising person. The position of this switch-off device shall make a sufficient overview on the respective work area possible.

(7) Where several control points are available, they shall be interlocked such that the lifting equipment is controllable from only one point.

(8) Wireless controls shall meet the requirements of DIN EN 60204-32, section 9.2.7.

6.5.4.2 Signalling systems

(1) The signalling systems shall differentiate between report signals, e.g. operational conditions or interlocks, warning signals, e.g. changes or imminent changes of operational conditions, and alarm signals effecting switching off.

(2) The report signals shall be optically displayed, warning and alarm signals both as optical and as acoustic signals.

(3) It shall be possible to test the optical displays and sound generators by actuating a test button.

(4) Optical displays shall remain actuated until the corresponding condition has been eliminated. When warning signals and alarm signals have been acknowledged, the optical displays shall change from blinking to continuous light and the acoustic signal shall be muted. Any subsequent warning or alarm signal shall reactivate the acoustic signal.

7 Increased requirements for cranes, winches, trolleys and load carrying devices

7.1 Structures

This section applies to the supporting structures of cranes, trolleys and winches.

7.1.1 Design

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

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 lifting device is allowed only if the parts in question are clearly separated from each other and the transmittal of internal forces within the overall structure can be gathered entirely as well as the load bearing characteristics of the entire structure are ascertained correctly. Where an analytical proof regarding external events is to be carried out, clause 4.5 (5) shall be taken into account.

(3) The following data shall be specified for dimensioning the supporting structures:

- a) erection loads including the corresponding working cycles over the intended deployment duration,
- b) operational loads including the corresponding working cycles over the intended deployment duration,
- c) loads from external events in accordance with section 4.5,
- d) ambient conditions in accordance with section 4.6.

7.1.2 Analytical proof

7.1.2.1 Analytical proof using the global safety factor concept according to DIN 15018-1

(1) The analytical proof shall be performed in accordance with **Annex B**, section B 2.1.1.

(2) The supporting structures shall be classified with respect to

- a) the maximum erection load: lifting class H1 and loading level group B2 according to DIN 15018-1.

b) the maximum operational load: lifting class H4 and loading level group B4 according to DIN 15018-1.

(3) Where a dynamic factor less than that resulting from (2) is to be used, the maximum dynamic load factor occurring 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 1.25.

(4) The loading resulting from shifting load shall be considered a special load case in accordance with DIN 15018-1 for the supporting structure.

(5) A verification of service strength need not be carried out if it can be demonstrated that the number of stress cycles is below $2 \cdot 10^4$. The number of stress cycles shall be determined in accordance with **Annex B**, section B 1.2.1.2.

(6) In the case of connections made with preloaded bolts to be re-assembled upon disassembly the following applies in addition to (5):

- a) Where a verification of service strength is to be carried out as per (5), the stress cycles resulting from disassembly and re-assembly operations shall be taken into account in the analysis.
- b) Where no verification of service strength is required as per subclause (5) and a maximum of 10 disassembly and re-assembly operations is carried out, a verification of service strength may be waived.
- c) Where more than 10 disassembly and re-assembly operations are carried out, a verification of service strength shall be carried out independently of the requirements of subclause (5). In this case, both the stress cycles from operational loadings and from disassembly and re-assembly operations shall be taken into account.

7.1.2.2 Analytical proof using the partial safety factors concept according to the standard series DIN EN 13001

(1) The stress analysis shall be performed in accordance with **Annex B**, section B 2.1.2.

(2) The supporting structures shall be classified with respect to

- a) the maximum erection load: stress history class S1 according to DIN EN 13001-3-1,
- b) the maximum operational load: stress history class S4 according to DIN EN 13001-3-1.

(3) The fatigue analysis need not be carried out if the conditions according to section 6.3.3 of DIN EN 13001-3-1 so permit. The number of stress cycles shall be determined in accordance with **Annex B**, section B 1.2.1.2.

(4) In the case of connections made with preloaded bolts to be re-assembled upon disassembly, the following applies in addition to (3):

- a) Where a fatigue analysis is to be carried out as per (3), 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. (3) and a maximum of 10 disassembly and re-assembly operations is carried out, the fatigue analysis may be waived.
- c) Where more than 10 disassembly and re-assembly operations are carried out, an analysis for cyclic operation shall be carried out independently of the conditions according to section 6.3.3 of DIN EN 13001-3-1. In this case, both the stress cycles from operational loadings and from disassembly and re-assembly operations shall be taken into account.

7.1.3 Design and structural requirements

The requirements of section 6.1.3 shall be met.

7.2 Hoists

This section applies to drive mechanisms and rope drives.

7.2.1 Drive mechanisms

This section applies to gear boxes, series gear boxes, series electric hoists, couplings and brakes.

7.2.1.1 Design

(1) The following data shall be specified for the design of drive mechanisms:

- a) erection loads including the pertinent working cycles over the intended deployment duration,
- b) operational loads including the pertinent working cycles over the intended deployment duration,
- c) dead load of the load suspension devices and supporting means,
- d) special loads, e.g. loads from the acceptance test, from in-service inspections, from test runs of the gear box, from actuation of the brakes, including the corresponding working cycles over the intended deployment duration,

Note :

When using systems to ascertain the braking effect without test load for in-service inspection, see also KTA 3903, Annex D, section D 3.1.

- e) duty cycle of the hoist under erection load, operational load and dead load as well as pertinent average hoisting speed and average travel path,
- f) duty cycle for which a lifting equipment with double drive mechanism chain shall be designed to manipulate the load after failure of one drive mechanism chain.
- g) ambient conditions in accordance with section 4.6.

(2) When dimensioning the hoists with a double drive mechanism chain, both drive mechanism chains shall be considered as mutually carrying the load under consideration of para 1 f). This does not apply to the brakes.

(3) The safety brake shall be designed for the maximum operational load with due consideration of the maximum possible failure load in the drive mechanism chain. The design moment shall be at least 1.4 times the static load moment. The braking distance of the safety brake for maximum possible failure load shall, basically, not exceed three times the braking distance of the service brake.

The following assumptions are permitted as basis for the analytical demonstration that the braking distance of the safety brake does not exceed three times the braking distance of the operational brake:

- a) The braking distance of the service brake may be calculated using the theoretical minimum braking torque (two times the static load moment) and the delay times of the brake and the control system to be expected.
- b) The braking distance of the safety brake may be calculated using the nominal values of delay times and braking torques.

The acceptability of larger braking distances shall be demonstrated for each individual case, where in the case of slow lowering speeds the acceptability - upon agreement with the authorized inspector - may be demonstrated by complying with a maximum allowable absolute value of the braking distance.

Note :

The braking distance of the service brake is understood to be the entire distance travelled from the moment of actuating the brakes by an "emergency-off" to total arrest of motion. The braking distance of the safety brake is understood to be the entire distance travelled from the moment of failure to total arrest of motion.

(4) The dimensioning of series-produced parts like brakes, brake discs, couplings, shall be based on the design data to be determined in accordance with the corresponding forms of KTA 3903, Annex C.

(5) The roller bearings shall be dimensioned on the basis of the calculation principles of the roller bearing manufacturer. Dynamic loads may be subjected to cubic averaging methods which shall be based on a probability of failure of 1 % to be taken with $a_1 = 0.21$. The maximum test load shall be considered to be the static (continuous) load.

7.2.1.2 Analytical proofs

The analytical proofs shall be performed in accordance with **Annex B**, section B 2.2.

7.2.1.3 Design and structural requirements

7.2.1.3.1 General

(1) Section 6.2.1.3.1 applies to hoists.

(2) In addition, hoists shall be equipped with a double drive mechanism chain or with a single drive mechanism chain with a safety brake.

(3) In the case of hoists with a double drive mechanism chain, redundancy is required for all mechanical parts in the load path according to sub-clause 2 (1) a), as well as for the brakes. This requirement does not apply to load hooks and the supporting structures of the top and bottom blocks.

(4) It shall be possible even during non-stationary operation to define the static condition of both drive mechanism chains.

(5) In the case of a single drive mechanism chain with safety brake, redundancy is required for the ropes and rope sheaves.

(6) The failure of a part within a double drive mechanism chain or within a single drive mechanism chain with safety brake shall initiate shutdown of the drive mechanism.

(7) If systems and auxiliary media (liquids, gases) are installed to take up or dampen a load shifting pulse, this system shall be monitored (e.g. pressure, filling level). Any impermissible deviation shall initiate shutdown of the drive mechanisms.

(8) In case of hoists for handling

a) fuel elements, rod cluster control elements and core instrumentation lances in pressurised water reactors,

b) fuel elements, control rods and fuel channels in boiling water reactors,

c) enclosures of core components

the loads arising at the load attachment points of these core components due to load shifting shall be limited.

The design shall ensure that the loads arising from load shifting do not lead to more unfavourable loadings at the load attachment points than those arising from the dead weight of the core component, multiplied by a load intensification factor of 4.

7.2.1.3.2 Gear boxes

Section 6.2.1.3.2 applies to the gear boxes.

7.2.1.3.3 Brakes

(1) Section 6.2.1.3.3 applies to brakes.

(2) In case of a break of the shaft or gear box, the safety brake shall engage on the rope drum or at the end of the drive mechanism chain. It shall be possible to safely set down the load by means of devices or operational measures.

7.2.2 Rope drives

This section applies to ropes, rope sheaves, rope drums, rope end terminations and the rope drum hinge connection.

7.2.2.1 Design

(1) Section 6.2.2.1 applies to the design of rope drives.

(2) In addition, the following applies: If the maximum operational load is applied in consideration of the dynamic loading upon failure of a part in a rope drive, then the rope diameter shall be such that after failure of a part in one rope drive a minimum safety against failure of 2.5 with respect to the rope minimum breaking strength is demonstrated in the other load-carrying rope drive.

(3) The design forces and moments for the rope drum hinge connections shall be increased by 20 %.

7.2.2.2 Analytical proofs

The analytical proofs shall be performed in accordance with **Annex B**, section B 2.2.4.

7.2.2.3 Design and structural requirements

(1) Section 6.2.2.3 applies to rope drives.

(2) In addition, in case of a single drive mechanism chain with a safety brake each rope drum shall be equipped with a support bearing that is designed such that the safety brake remains effective in the case of a break in the shaft or gear box and that the load can be safely set down in the case of a failure of a drum bearing or break of the drum trunnion.

7.3 Lateral transport drives

This section applies to the wheel bearings and wheels, wheel axles and shafts.

7.3.1 Design

Section 6.3.1 applies to the design of lateral transport drives.

7.3.2 Analytical proofs

The analytical proofs shall be performed in accordance with **Annex B**, section B 1.3.

7.3.3 Design and structural requirements

Section 6.3.3 applies to the design and structural requirements of lateral support drives.

7.4 Load carrying devices

This section applies to supporting means, load suspension devices and lifting accessories.

7.4.1 Supporting means

This section applies to jigs and fixtures permanently connected to the lifting equipment for the purpose of attaching load suspension devices, lifting accessories, or loads (e.g. load hooks, load hook mountings, grabs, lifting beams, hangers as well as top and bottom blocks and the mountings for compensation pulleys and rope end terminations).

7.4.1.1 Design

(1) The load hooks shall be classified with respect to the drive mechanism groups in accordance with sub-clauses

6.4.1.1 (1) and (2), however, with respect to the operational load at least in drive mechanism group 3_m.

(2) The design of supporting means as supporting structures shall be in accordance with the requirements of section 7.1.1 and the design of supporting means as machine parts in accordance with section 7.2.1.1.

(3) In the case of non-redundant supporting means 1.25 times the dynamic factor shall be used in the analysis. Para. 1 applies to the load hook.

(4) 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 tensional 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 both in the stress analysis and the fatigue analysis. These requirements need not be met if bolts according to KTA 3903, Annex A, materials test sheet WPB 3.17 are used.

7.4.1.2 Analytical proofs

(1) The analytical proofs shall be performed in accordance with **Annex B**, section B 2.4.

(2) The stipulations of clauses 6.4.1.2 (2) and 6.4.1.2 (3) apply.

7.4.1.3 Design and structural requirements

The requirements of section 6.4.1.3 apply.

7.4.2 Load suspension devices

This section applies to jigs and fixtures not belonging to the lifting equipment, which can be connected to the supporting means of the lifting equipment for the purpose of attaching the load, e.g. load hooks, load hook mountings, lifting beams, hangers and grabs.

7.4.2.1 Design

(1) The design of load suspension devices as supporting structures shall be in accordance with the requirements of section 7.1.1 and the design of load suspension devices as machine parts in accordance with section 7.2.1.1.

(2) Section 7.4.1.1 applies to load hooks.

(3) In the case of non-redundant load suspension devices 1.25 times the dynamic factor shall be used in the analysis.

(4) The requirements of sub-clauses 6.4.2.1 (3) and of 7.4.1.1 (4) apply.

7.4.2.2 Analytical proofs

The requirements of section 7.4.1.2 apply.

7.4.2.3 Design and structural requirements

The requirements of section 6.4.2.3 apply.

7.4.3 Lifting accessories

The requirements of section 6.4.3 apply.

7.5 Electrical equipment

The requirements of section 6.5 shall be met. In addition to section 6.5, the following applies:

a) The loss of one outer conductor of the hoist motor or drive converter power supply shall automatically lead to an all-

phase switch-off of the hoist motor. The loss of one outer conductor shall trigger an alarm signal at the control points.

- b) In the case of hoists with a single drive mechanism chain a monitoring device shall be provided to engage the safety brake in case of damage caused by break of the shaft or gear box. Where, in case of failure of this function, an event beyond the accident planning reference levels of § 104 of the Radiation Protection Ordinance is to be assumed and where the function is provided by means of software-based systems, monitoring of hoists with a maximum operational load greater than 5 t shall be ensured by two independent and varying devices (for examples see **Figures E-2 and E-4**). In this case, one of the monitoring devices shall detect the break of the shaft or gear box by continuous comparison of rotational movement of the drive motor and the rope drum. The engagement of the safety brake at hoist movement shall be recorded by a meter. The non-disengaging of the safety brake shall be monitored.
- c) The reinstatement to operation after failure of a part in one drive mechanism chain shall only be possible by means of a key switch in the electrical operation room.
- d) Where, in case of failure of the safety travel limiter at the hoist gear travel end, an event beyond the accident planning reference levels of § 104 of the Radiation Protection Ordinance is to be assumed and where the function is to be provided by means of software-based systems, switching-off in case of excess of the allowable speed and of the safety travel limiter shall be effected by two independent and varying devices (for examples see **Figures E-1, E-3 and E-4**).
- e) The failure of a part in a double drive mechanism chain or in a drive mechanism chain with safety brake shall lead to a shutdown of the drive mechanism and shall trigger an alarm signal at the control points.
- f) If systems and auxiliary media (liquids, gases) are provided to take up or dampen a load shifting pulse, this system shall be monitored (e.g. pressure, filling level). Any impermissible deviation shall initiate arrest of motion and shall trigger an alarm signal at the control points.
- g) A continuous load indicator shall be provided at the control points.
- h) If for certain transports a limitation of the load in the part-load area of the maximum operational load is required, it shall be ensured in addition to the overload protection as per 6.5.2 (4) that further limit values for overload can be adjusted.

8 Requirements for refueling machines for light water reactors

8.1 Structures

This section applies to the supporting structures of cranes and trolleys.

8.1.1 Design

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

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 lifting device is allowed only if the

parts in question are clearly separated from each other and the transmittal of internal forces within the overall structure can be gathered entirely as well as the load bearing characteristics of the entire structure are ascertained correctly. Where an analytical proof regarding external events is to be carried out, clause 4.5 (5) shall be taken into account.

(3) The following data shall be specified for dimensioning the supporting structures:

- a) operational loads including the pertinent working cycles over the intended deployment duration,
- b) loads from external events in accordance with section 4.5,
- c) ambient conditions in accordance with section 4.6.

8.1.2 Analytical proof

8.1.2.1 Analytical proof using the global safety factor concept according to DIN 15018-1

(1) The analytical proof shall be performed in accordance with **Annex B**, section B 2.1.1.

(2) The supporting structures shall be classified with respect to the maximum operational load in lifting class H4 and loading level group B4 in accordance with DIN 15018-1.

(3) Where a dynamic factor less than that resulting from (2) is to be used, the maximum dynamic load factor occurring 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 1.25.

(4) The loadings resulting from load shifting shall be considered a special load case in accordance with DIN 15018-1 for the supporting structure.

(5) A verification of service strength need not be carried out if it can be demonstrated that the number of stress cycles is below $2 \cdot 10^4$. The number of stress cycles shall be determined in accordance with **Annex B**, section B 1.2.1.2.

(6) In the case of connections made with preloaded bolts to be re-assembled upon disassembly the following applies in addition to (5):

- a) Where a verification of service strength is to be carried out as per (5), the stress cycles resulting from disassembly and re-assembly operations shall be taken into account in the analysis.
- b) Where no verification of service strength is required as per subclause (5) and a maximum of 10 disassembly and re-assembly operations is carried out, a verification of service strength may be waived.
- c) Where more than 10 disassembly and re-assembly operations are carried out, a verification of service strength shall be carried out independently of the requirements of subclause (5). In this case, both the stress cycles from operational loadings and from disassembly and re-assembly operations shall be taken into account.

8.1.2.2 Analytical proof using the partial safety factors concept according to the standard series DIN EN 13001

(1) The stress analysis shall be performed in accordance with **Annex B**, section B 2.1.2.

(2) The supporting structures shall be classified with respect to the maximum operational load: stress history class S4 according to DIN EN 13001-3-1.

(3) The fatigue analysis need not be carried out if the conditions according to section 6.3.3 of DIN EN 13001-3-1 so per-

mit. The number of stress cycles shall be determined in accordance with **Annex B**, section B 1.2.1.2.

(4) In the case of connections made with preloaded bolts to be re-assembled upon disassembly, the following applies in addition to (3):

- a) Where a fatigue analysis is to be carried out as per (3), 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. (3) and a maximum of 10 disassembly and re-assembly operations is carried out, the fatigue analysis may be waived.
- c) Where more than 10 disassembly and re-assembly operations are carried out, an analysis for cyclic operation shall be carried out independently of the conditions according to section 6.3.3 of DIN EN 13001-3-1. In this case, both the stress cycles from operational loadings and from disassembly and re-assembly operations shall be taken into account.

8.1.3 Design and structural requirements

(1) The requirements of section 6.1.3 apply.

(2) The refueling machines shall be constructed such that corresponding compensation measures counteract the deflection of the bridge girders in order to make vertical lifting possible during insertion and removal of fuel assemblies.

8.2 Hoists

This section applies to drive mechanisms and rope drives.

8.2.1 Drive mechanisms

This section applies to gear boxes, series gear boxes, couplings and brakes.

8.2.1.1 Design

(1) The following data shall be specified for the design of drive mechanisms:

- a) operational loads including the pertinent working cycles over the intended deployment duration,
- b) dead load of the load carrying device,
- c) special loads, e.g. loads from the acceptance test, from in-service inspections, from test runs of the transmission, from actuation of the brakes, including the corresponding working cycles over the intended deployment duration,

Note:

When using systems to ascertain the braking effect without test load for in-service inspection, see also KTA 3903, Annex D, section D 3.1.

- d) duty cycle of the hoist under operational load and dead load as well as pertinent average hoisting speed and average travel paths,
- e) duty cycle for which a lifting equipment with double drive mechanism chain shall be designed to manipulate the load after failure of one drive mechanism chains.
- f) ambient conditions in accordance with section 4.6.

(2) When dimensioning the hoists with a double drive mechanism chain, both drive mechanism chains shall be considered as mutually carrying the load under consideration of para. (1) e). This does not apply to the brakes.

(3) The safety brake shall be designed for the maximum operational load with due consideration of the maximum possible failure load in the drive mechanism chain. The design moment shall be at least 1.4 times the static load moment. The braking distance of the safety brake for

ble failure load shall basically not exceed three times the braking distance of the service brake.

The following assumptions are permitted as basis for the analytical demonstration that the braking distance of the safety brake does not exceed three times the braking distance of the service brake:

- a) The braking distance of the service brake may be calculated using the theoretical minimum braking torque (two times the static load moment) and the delay times of the brake and the control system to be expected.
- b) The braking distance of the safety brake may be calculated using the nominal values of delay times and braking torques.

The acceptability of larger braking distances shall be demonstrated for each individual case, where in the case of slow lowering speeds the acceptability - upon agreement with the authorized inspector - may be demonstrated by complying with a maximum allowable absolute value of the braking distance.

Note:

The braking distance of the service brake is understood to be the entire distance travelled from the moment of actuating the brakes by an "emergency-off" to total arrest of motion. The braking distance of the safety brake is understood to be the entire distance travelled from the moment of failure to total arrest of motion.

(4) The dimensioning of series-produced parts like brakes, brake discs, couplings, shall be based on the design data to be determined in accordance with the corresponding forms of KTA 3903, Annex C.

(5) The roller bearings shall be dimensioned on the basis of the calculation principles of the roller bearing manufacturer. Dynamic loads may be subjected to cubic averaging methods which shall be based on a probability of failure of 1 % to be taken with $a_1 = 0.21$. The maximum test load shall be considered to be the static (continuous) load.

8.2.1.2 Analytical proofs

The analytical proofs shall be performed in accordance with **Annex B**, section B 2.2.

8.2.1.3 Design and structural requirements

8.2.1.3.1 General

- (1) Section 6.2.1.3 applies to hoists.
- (2) In addition, hoists shall be equipped with a double drive mechanism chain or with a single drive mechanism chain with a safety brake.
- (3) In the case of hoists with a double drive mechanism chain, redundancy is required for all mechanical parts in the load path according to sub-clause 2 (1) a), as well as for the brakes. This requirement does not apply to grabs and their load guides.
- (4) It shall be possible even during non-stationary operation to define the static condition of both drive mechanism chains.
- (5) In the case of a single drive mechanism chain with safety brake, redundancy is required for the ropes and rope sheaves.
- (6) The failure of a part within a double drive mechanism chain or within a single drive mechanism chain with safety brake shall initiate shutdown of the drive mechanism.
- (7) Slack rope monitoring shall be carried out and equipment for a continuous measurement of the load be provided.
- (8) It must be possible to set down the fuel assembly in a safe position, even in the case of power failure or failure of a part in the drive mechanism.

(9) The movements of all manually operated parts, with the exception of the emergency drives, shall be limited in a reliable way.

(10) If systems and auxiliary media (liquids, gases) are installed to take up or dampen a load shifting pulse, this system shall be monitored (e.g. pressure, filling level). Any impermissible deviation shall initiate arrest of motion.

(11) In case of hoists for handling

- a) fuel elements, rod cluster control elements and core instrumentation lances in pressurised water reactors,
- b) fuel elements, control rods and fuel channels in boiling water reactors,
- c) enclosures of core components

the loads arising at the load attachment points of these core components due to load shifting shall be limited.

The design shall ensure that the loads arising from load shifting do not lead to more unfavourable loadings at the load attachment points than those arising from the dead weight of the core component, multiplied by a load intensification factor of 4.

8.2.1.3.2 Gear boxes

Section 6.2.1.3.2 applies to the gear boxes.

8.2.1.3.3 Brakes

- (1) Section 6.2.1.3.3 applies to brakes.
- (2) In the case of a break of the shaft or gear box, the safety brake shall engage on the rope drum or at the end of the drive mechanism chain. It shall be possible to safely set down the load by means of devices or operational measures.

8.2.2 Rope drives

This section applies to ropes, rope sheaves, rope drums, rope end terminations and the rope drum hinge connection.

8.2.2.1 Design

- (1) Section 6.2.2.1 applies to the design of rope drives.
- (2) In addition to section 6.2.2.1, if the maximum operational load is applied in consideration of the dynamic loading upon failure of a part in a rope drive, then the rope diameter shall be such that after failure of a part in one rope drive a minimum safety against failure of 2.5 with respect to the rope minimum breaking strength is demonstrated in the other load-carrying rope drive.
- (3) The design forces and moments for the rope drum hinge connections shall be increased by 20 %.

8.2.2.2 Analytical proofs

The analytical proofs shall be performed in accordance with **Annex B**, section B 2.2.4.

8.2.2.3 Design and structural requirements

- (1) Section 6.2.2.3 applies to rope drives.
- (2) In addition, each rope drum shall be equipped with a support bearing that is designed such that the safety brake remains effective in the case of a break in the shaft or gear box or that the load can be safely set down in the case of a failure of a drum bearing or break of the drum trunnion.

8.3 Lateral transport drives

This section applies to the wheel bearings and wheels, wheel axles and shafts.

8.3.1 Design

Section 6.3.1 applies to the design of lateral transport drives.

8.3.2 Analytical proofs

The analytical proofs shall be performed in accordance with **Annex B**, section B 1.3.

8.3.3 Design and structural requirements

Section 6.3.3 applies to the design and structural requirements of lateral support drives.

8.4 Load carrying devices

This section applies to grabs and load guides of refueling machines, e.g. telescoping mast and guide tube.

8.4.1 Design

(1) The design of load guides as supporting structures shall be in accordance with the requirements of section 8.1 and the design of grabs in accordance with section 8.2.

(2) For non-redundant parts 1.25 times the dynamic factor shall be used in the analysis.

(3) 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 tensional 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 both in the stress analysis and the fatigue analysis. These requirements need not be met if bolts according to KTA 3903, Annex A, materials test sheet WPB 3.17 are used.

8.4.2 Analytical proofs

(1) The analytical proofs shall be performed in accordance with **Annex B**, section B 2.4.

(2) The stipulations of clauses 6.4.1.2 (2) apply.

8.4.3 Design and structural requirements

(1) The load shall be attached in a positive-locking way only.

(2) The grabs shall be interlocked in two independent ways against unintentional opening and opening in locations that are non-permissible for safety reasons. This also applies in the case of complete or partial power failure (electricity, hydraulics, pneumatics).

(3) It must be possible to set down the fuel assembly in a safe position, even in the case of a power failure.

8.5 Electrical equipment

The requirements of sections 6.5 and 7.5 shall be met, however, the realization of the safety functions as per sub-clause 7.5 b) or 7.5 d) is not required by means of two different systems. In addition to the requirements of sections 6.5 and 7.5, the following applies:

- a) The end positions "open" and "closed" of the grabs and all related interlocks shall be optically displayed at the control points. No movement of the hoist shall be possible before any of the two end positions is reached.
- b) It shall not be possible to actuate the switch for the power supply to the refueling machine unless this actuation has been released, either by means of a key-operated switch or similarly safe switching means from the reactor control room or from a location comparable from a safety point of view. Communication shall be possible between this location and all control points, either directly or through an intercommunication system connected to a continuous power supply. The action of taking back the clearance may not trigger turning-off of the power supply switch; it shall, however, prevent a reactivation of the power supply switch after it has been turned off.
- c) The position of the fuel assembly grabs shall be displayed with all coordinates.
- d) The continuous load measurement device on the control console shall be equipped with a display of the actual load attached to the rope. For certain assigned loads, e.g. fuel assemblies or control rods, specifically assigned limit values depending on the type of operation shall automatically be activated in the case of overload or underload and switch off the hoist.
- e) The response of any limit load monitor and the response of the slack-rope monitor shall trigger an alarm signal at the control points.
- f) Lateral movements shall be interlocked such that they are only possible if the grab has reached the allowable altitude permitted for the respective operation.
- g) In order to limit the lateral movements to the travel area permitted with regard to safety which is defined by the contour of the reactor and fuel pool areas as well as by fixed internals, an independent safety travel limiter shall be provided in addition to the operational travel limiter according to clause 6.5.3 (1).
- h) If parts of the refueling machine can be moved both manually and by motors, turning on of the motor drive is not allowed and shall be made impossible as long as a manual movement can be performed.
- i) In the case of hoists with telescope mast the correct sequence of mast sections during extension and retraction of the telescope mast shall be monitored. In the case of hoists with double grab the correct sequence during extension and retraction of the movable parts (centring bell, fuel assembly grabs, control rod grabs) shall be monitored.
In case of failure the hoist shall be switched off.
- j) The setting down of a transported load (e.g. fuel element) on an already occupied position in the fuel pool or reactor core shall be prevented by an interlock.
- k) The electrical interlock according to clause 6.5.2 (10) shall be designed such that the control command for the detachment of the load can only be executed at simultaneous release of two independent criteria (e.g. hoisting height and load).
- l) It shall be ensured by interlocking that, when passing over the BWR flooding compensator or the PWR reactor vessel cavity seal, no lifting or lowering movement of the main hoist is possible.

Annex A

Examples for classification of lifting equipment

A 1 Examples for classification of lifting equipment in Pressurized Water Reactor plants

Serial number	Lifting equipment	Additional requirements in accordance with section 4.2	Increased requirements in accordance with section 4.3
1	Reactor building crane except for maintenance hoist		X
2	Semi-gantry crane		X
3	Walking crane inside the reactor building	X	
4	Crane in new fuel storage	X	
5	Auxiliary hoist on the refueling machine		X
6	Lifting beam for radiation protection slabs above the reactor pool and set-down pool		X
7	Lifting beam for the cover of the reactor pressure vessel		X
8	Lifting beam for the irradiated fuel shipping cask		X
9	Lifting beam for the shipping cask for fresh UO ₂ fuel assemblies	X	
10	Lifting beam for the metallic contamination protection shroud	X	
11	Lifting beam for reactor pressure vessel internals: - upper core structure - lower core structure	X	X
12	Lifting beam for refueling slot gates		X
13	Lifting beam for the stud tensioner of the reactor pressure vessel cover	X	

A2 Examples for classification of lifting equipment in Boiling Water Reactor plants

Serial number	Lifting equipment	Additional requirements in accordance with section 4.2	Increased requirements in accordance with section 4.3
1	Reactor building crane except for maintenance hoist		X
2	Crane in new fuel storage	X	
3	Auxiliary hoist on the refueling machine		X
4	Winch for handling irradiated fuel assemblies in the storage pool		X
5	Lifting beam for the cover of the reactor pressure vessel and containment and for the flooding compensator		X
6	Lifting beam for radiation protection slabs of the reactor pool and set-down pool		X
7	Lifting beam for refueling slot gates		X
8	Lifting beam for steam separator and steam dryer		X
9	Lifting beam for the irradiated fuel shipping cask inside the reactor building		X
10	Lifting beam for the shipping cask for fresh UO ₂ fuel assemblies inside the reactor building	X	
11	Lifting beam for the metallic contamination protection shroud	X	
12	Lifting beam for the stud tensioner of the reactor pressure vessel cover	X	