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Allgemeine bauaufsichtliche Zulassung Z-30.3-6 of 20 April 2009

„Products, fasteners, structural parts made of stainless steels“

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Deutsches Institut für Bautechnik
DIBt

Allgemeine bauaufsichtliche Zulassung

Zulassungsstelle für Bauprodukte und Bauarten
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Subject of approval:
Products, fasteners, structural parts made of stainless steels

The subject of approval mentioned above is herewith generally approved in the field of construction. This *allgemeine bauaufsichtliche Zulassung* ('national technical approval') comprises 28 pages**) and 33 Annexes.

An *allgemeine bauaufsichtliche Zulassung* (national technical approval) was granted for this construction product for the first time on 31 May 1974.

*) With amendment of 02 May 2011 **) The number of pages refers to the original approval

I GENERAL PROVISIONS

1 With the *allgemeine bauaufsichtliche Zulassung* ('national technical approval') the fitness for use and the applicability of the subject of approval according to the *Landesbauordnungen* ('Building Regulations of the Land') has been verified.

2 If, in the *allgemeine bauaufsichtliche Zulassung* ('national technical approval') requirements are made concerning the special expertise and experience of persons entrusted with the manufacture of construction products and types of construction according to the relevant regulations of the Land following section 17, sub-section 5 *Musterbauordnung* ('Model Building Code'), it is to be noted that this expertise and experience can also be proven by equivalent verifications from other Member States of the European Union. If necessary, this also applies to verifications presented within the framework of the Agreement on the European Economic Area (EEA) or other bilateral agreements.

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7 The *allgemeine bauaufsichtliche Zulassung* ('national technical approval') is granted until revoked. The provisions of the *allgemeine bauaufsichtliche Zulassung* ('national technical approval') can subsequently be supplemented and amended in particular, if this is required by new technical findings.

II SPECIFIC PROVISIONS

1 Subject of approval and field of application

1.1 Subject of approval

Subject of approval are products and fasteners made of stainless steels according to DIN EN 10088-1:2005-09 as well as components and their connections produced from them according to DIN 18800-1 to -4 and -7:2008-11, and the engineering standards mentioned in section 1.2.

The steel grades and their product forms for components are given in Annex 1, Table 1. Stainless steels for components are used in the strength classes S235, S275, S355, S460 and S690, where the strength classes are indicated in N/mm² according to the yield strengths $R_{p0.2}$. The strengths following each the lowest one are achieved through cold working.

Stainless steels for fasteners are assigned to steel groups according to DIN EN ISO 3506-1 and -2:2010-04 in the strength classes 50, 70 and 80, where the strength classes are indicated in kN/cm² according to the tensile strengths R_m.

Components may be the products themselves or produced from them according to given rules. Products shall have a minimum thickness of min t or rather min d = 1.5 mm, the thread diameters of the fasteners shall be at least M 6.

Not subject of this national technical approval are:

- high-strength tension members according to DIN 18800-1:2008-11
- multi-part compression members according to DIN 18800-2:2008-11
- composite structures made of steel and concrete according to DIN 18800-5:2007-03
- structural parts made of hollow sections according to DIN 18808:1984-10 of the strength classes S460 and S690
- free-standing steel chimneys according to DIN V 4133:2007-07
- rivets according to DIN 18800-1:2008-11

1.2 Field of application

This national technical approval applies to components and connections under predominantly static loads

- in steel structural engineering according to DIN 18801:1983-09,
- in supporting structures made of hollow section according to DIN 18808:1984-10 up to strength class S355,
- in round thin-walled silos according to DIN 18914:1985-09,
- in above-ground cylindrical flat-bottom tanks according to DIN 4119-1:1979-06 and
- in steel radio towers and masts according to DIN V 4131:2008-09.

together with DIN 18800-1 to -4 and -7:2008-11 and, as far as this concerns engineering standards, of the *Anpassungsrichtlinie Stahlbau* ('adjustment directive for steel structures') with modification and supplement - edition December 2001.

For façade components and their anchoring elements and fasteners, section 3.3.11 shall be taken into account for pulsating and alternating load through atmospheric changes of temperature.

For assessing their corrosion resistance, stainless steels are divided into corrosion resistance classes; see Annex 1, Table 1. The selected corrosion resistance classes shall fulfill the requirements put on the components for corrosion protection, also with regard to the time of protection.

The steel grades mentioned in Table 1 can be applied for temperatures down to -40 °C. This does not require any proof for austenitic steels. For the steel grades of the material numbers 1.4003, 1.4016, 1.4362 and 1.4462, a sufficient notched-bar impact value with ISO-V-samples shall be proven.

2 Characteristics of the construction product

2.1 Production, properties and composition of products and fasteners

2.1.1 Steel grades, product forms, strength classes

The products consist of steel grades in the product form according to Annex 1, Table 1 and the fasteners of strength classes according to Annex 2, Table. 2.

2.1.2 Technical delivery conditions for prodcuts according to Table 1 of Annex 1

2.1.2.1 Products without or before cold working

The technical delivery conditions apply according to:

- DIN EN 10088-4:2010-01 for sheet/plate and strip,
- DIN EN 10088-5:2009-07 for bars, rods, wire and sections,
- DIN EN 10296-2:2006-02 for welded tubes,
- DIN EN 10297-2:2006-02 for seamless tubes.

2.1.2.2 Products after cold working

The steel grades for products according to Table 1 given in Annex 3, Table 3 shall have the mechanical properties given there at ambient temperature. The proofs shall be furnished such as it is established in the standards in section 2.1.2.1 for the state before cold working.

2.1.2.3 Choice of steel grade classes

The recommendation given in DIN 18800-1:2008-11, element 403, applies analogously. Accordingly, stainless steels shall meet the same requirements as common carbon steels with regard to notched-bar impact work. Since austenitic stainless steels are not susceptible to brittle fracture up to temperatures of -40 °C, t hey can be applied up to these temperatures without any further proof.

For ferritic steels with the material numbers 1.4003 and 1.4016 as well as for the austenitic-ferritic steel grades with the material numbers 1.4362 and 1.4462 at least one notched-bar impact work of 40 J with ISO-V-samples shall be proven at -40 °C. For long products the proof shall be furnished on longitudinal samples and for flat products on transverse samples. The value of the notched-bar impact work is determined as mean value of 3 samples, where at most one single value around maximum 30 % may be below 40 J.

2.1.3 Technical terms of delivery for fasteners according to Annex 2, Table 2

The technical terms of delivery apply according to:

- DIN EN 15048-1:2007-07
- DIN EN ISO 3506-1:2010-04 for screws and threaded rods,
- DIN EN ISO 3506-2:2010-04 for nuts, and as far as applicable, also for washers.

2.1.4 Suitability for welding; filler metals

2.1.4.1 General

Except for steel grades with the material numbers 1.4016, 1.4567 and 1.4578, as far as approved filler metals are available according to 2.1.4.2 and no restrictions are made in 4.6.2 to 4.6.8, all steels grades are approved for the following welding processes:

Manual metal arc welding (111), tungsten inert gas welding (141), metal inert gas welding (131), metal active gas welding (135), tubular cored metal arc welding with active gas shield (136), submerged arc welding (12), arc stud welding (783), drawn arc stud welding with tip ignition (786), plasma MIG welding (151), resistance spot welding (21), flash welding (24), resistance butt welding (25), friction welding (42), laser beam welding (52) and electron beam welding (51).

Welding of the steel grades with the material numbers 1.4016, 1.4567 and 1.4578 is not regulated in this national technical approval.

2.1.4.2 Welded joints, filler metals

(1) Except for joints of components made of the same stainless steel grades according to this national technical approval, such joints of components made of different steel grades - hereafter named mixed joints - are allowable. It may concern components made of:

- different stainless steel grades according to this national technical approval
- stainless steel grades according to this national technical approval and carbon steels according to DIN 18800-1:2008-11 as well as technically approved high-strength carbon steels.

(2) Welding consumables for joints of components with the same stainless steel grades are indicated in Annex 4, Table 4.

(3) In welded joints made of different austenitic steel grades according to Table 1, the filler metals of one as well as of the other steel grade may be applied according to Table 4.

(4) In welded joints of components made of austenitic steel grades and such of the ferritic steel grade with the material number 1.4003 filler, metals shall be used according to Annex 5, Table 5. Thermal conduction shall be oriented towards austenitic steel.

(5) In mixed joints of components made of the ferritic steel grade with the material number 1.4003 or austenitic steel grades on the one hand and such made of carbon steels according to DIN 18800-1:2008-11 as well as of the technically approved high-strength carbon steels on the other hand, filler metals according to Annex 5, Table 6 shall be used. Thermal conduction is oriented to that for high-strength carbon steels, where preheat temperatures and interpass temperatures above 150 ℃ shall be av oided. Incidentally, DIN EN 1011-2:2001-05 shall be taken into account for fine grain steels.

(6) In mixed joints of components made of ferritic-austenitic steel grades with the material numbers 1.4362 or 1.4462 on the one hand and components made of carbon steels according to DIN 18800-1:2008-11 as well as the technically approved high-strength carbon steels on the other hand, the filler metal given for the steel grades with the material numbers 1.4362 and 1.4462 in Table 4 shall be preferred. The filler metals according to Annex 6, Table 7 may also be used. Paragraph (5) applies for thermal conduction.

2.1.5 Limit dimensions of the products and fasteners

2.1.5.1 Limit dimensions of the products

The products or rather their sections shall have a thickness of at least 1.5 mm.

Unless no additional restrictions are made in other sections of this national technical approval, to the maximum thicknesses apply

- the specifications in DIN EN 10088-4:1012-01 and DIN EN 10088-5:2009-07 of annealed products and
- the specifications in Annex 6, Table 8 of cold-worked products.

The maximum thicknesses for welded components of cold-worked and annealed materials result from Tables 8 and 9 in Annex 6 and 7.

2.1.5.2 Limit dimensions of the fasteners

The minimum diameter of thread is M 6.

For different steel grades, the maximum nominal diameters result from Table 2. The mechanical properties according to DIN EN ISO 3506-1 and -2:2010-04 shall also be ensured for the dimension ranges mentioned here compared to the standard as well as checked and controlled according to section 2.3.

2.1.6 Corrosion protection of the construction products

2.1.6.1 Requirements

(1) For reasons of stability, components and fasteners require no corrosion protection, if

- the material used corresponds to corrosion resistance class according to Table 1, which is at least required after corrosion load according to Table 1a, and
- no deviating requirements result from sections 2.1.6.2 to 2.1.6.7.

Note:

Corrosion resistance classes integrate different alloys showing a comparable corrosion resistance under the same corrosion loads. The selection of materials according to Table 1a only includes technical requirements, but not decorative consistency (e.g. unwanted discolorations in consequence of a slight corrosive attack).

If there are high optical requirements, a particular importance is attached to type of design and surface finish of the components. Finely machined, smooth and flawless surfaces shall be ensured. The selection of a higher corrosion resistance class offers no replacement for this. The factory deliverable surfaces 2B, 2R, 1G, 2G, 1K, 2K for sheet/plate and strip or 1G, 2G, 2B and 2P for bars, rods, wire and sections specified in DIN EN 10088-4:2010-01 or DIN EN 10088-5:2009-07 meet these requirements.

(2) In each single case it shall be checked what kind of corrosion load can be expected for the particular structure or structural part.

2.1.6.2 Corrosion protection of components and fasteners in indoor swimming pools

Under the conditions mentioned in Annex 7, Table 10, only the steel grades given there shall be used in indoor swimming pools.

2.1.6.3 Corrosion protection of welded or thermally cut components

(1) In the corrosion resistance classes III and IV, a post-treatment of the cutting edge and the welds is always necessary to remove annealing colours. Welds shall be constructional arranged in a way that areas in which annealing colours cannot be removed (e.g. in gaps and in overlaps) are completely closed through the weld. In exceptional cases, open gaps and overlaps can be protected through sealing by suitable sealant against entry of corrosive media.

The removal of annealing colours and the closure of gaps and overlap areas is dispensable, if they are constructively arranged in such areas for which input and accumulation of corrosion causing media can be safely excluded.

For minimizing on-site welding work, especially for structures for which a suitable post-treatment is aggravated through accessibility, system solutions with a high degree of factory prefabrication and defined surface conditions shall be prioritized.

For the corrosion resistance classes I and II, darker annealing colours darker than straw-yellow shall be removed.

Notice: Annealing colours developing on the back of a steel component due to the heat input from the welding process may remain if the affected surface abuts on a solid component and coupled with it, e.g. welding to anchor plates.

(2) To avoid a sensitization against intergranular corrosion after welding, the highest thicknesses according to Annex 7, Table 9 shall be taken into account for the steel grades with the numbers 1.4301 and 1.4401.

(3) For welded joints of stainless steel with other steel, the explanations regarding bimetal corrosion (contact corrosion) in section 2.1.6.5 apply.

2.1.6.4 Corrosion protection of mechanically treated components

During mechanical treatment of stainless steels as well as removal of annealing colours according to section 2.1.6.3, no particles producing extraneous rust shall get into the surface. An application of tools by means of which non-alloy or low-alloy steel was previously treated or wire brushes made of such steels shall be avoided accordingly. If this is impossible in the single case, the surface for removing the particles producing extraneous rust shall be post-processed (e.g. etching, grinding).

Notice: Annealing colours developing through mechanical cutting, for example on cut edges, may remain.

2.1.6.5 Corrosion protection of connections with other metals

(1) Bimetal corrosion may occur for an electrically conductive contact of different metals. The appearance of bimetal corrosion is bounded to the existence of a liquid (electrolyte solution) in the contact area, i.e. an endanger basically exists only if the corresponding joint is often and long-lasting moist. In the most general sense, bimetal corrosion in an aqueous environment (also in the soil) has a bigger significance than at the atmosphere where it is only effective as long as water does not dry off. If there are impurities, hydroscopic or constantly damp deposits, self-priming sealings or constantly dump crevices, damages through bimetal corrosion are possible even under conditions of a usually harmless atmospheric load.

(2) On joints with components made of non-alloy or low-alloy steel, galvanized steel or aluminum for example, a corrosion risk through bimetal corrosion may only exist for the less noble contact materials; bimetal corrosion practically does not occur on stainless steels themselves.

(3) If necessary, bimetal corrosion shall be prevented by isolating stainless steel electrically from less noble metal through suitable plastics molding. Electric isolation shall be complete and also must not be abolished indirectly offside the joints. If necessary several components shall be coated in order to achieve a protection of the less noble partner from bimetal corrosion.

(4) Welds shall be arranged in that way that the position of the contact area does not expect any corrosion (e.g. inner areas without condensation). Otherwise, the joint shall receive a corrosion protection granting a constant protection for the non-alloy and low alloy steel in dependence on the corrosiveness of the environment and on the protection period. The selected corrosion protection shall be extended at least to the directly adjacent area of the stainless steel in order to avoid the formation of corrosion cells in the transition area.

2.1.6.6 Galvanizing, contact with molten zinc

Hot-dip galvanizing of components made of stainless steels is not allowed. When coming into contact of stainless steel with molten zinc which may occur upon hot-dip galvanizing - i.e. of components with mixed joints - or in the event of fire, the risk of an immediate embrittlement exists. This contact shall not be excluded if the stability of the structure is not jeopardized through an embrittlement of the stainless steel.

2.1.6.7 Corrosion protection of anchoring, reinforced concrete construction and in masonry construction.

Welded joints and other metallically conductive contact points between stainless steels and other steel grades are only allowable without additional corrosion protection, if that part of the stainless steel free of annealing colours weaves at least 5 cm into the concrete.

2.2 Package, transport, storage and marking of the products and the fasteners

2.2.1 Package, transport, storage

The products and fasteners shall be packed, transported and stored this way that the material and corrosion behaviour is considered. The contamination of particles producing extraneous rust into the surface shall also be avoided. If this is impossible in the single case, the surface for removing the particles producing extraneous rust shall be post-processed (e.g. etching, grinding).

2.2.2 Marking

2.2.2.1 Products

(1) For CE-marking and labelling of the annealed products the provisions in DIN EN 10088-4:2010-01 or DIN EN 10088-5:2009-07, Annex ZA apply.

Cold-worked products or the enclosed leaflet shall be marked by the manufacturer with the conformity mark Ü (Ü-mark) in accordance with the decrees on conformity marking of the States of the Federal Republic of Germany. The name of the manufacturer and the number of this national technical approval shall be declared in the conformity mark. Marking is only allowed if the conditions given in section 2.3 are satisfied.

Furthermore the products shall be marked according to DIN EN 10088-4:2010-01 or DIN EN 10088-5:2009-07, Section 9.

(2) The marking according to paragraph (1) shall be preserved if only parts of the products are used. If necessary the marking shall be transferred to the single parts by a person in charge of the manufacturer. An in-house defined short mark may be used for the marking of small parts (meant are small parts of the initial products as bars and not small parts of a fabricator as e. g. anchor channels). All cutting of the products shall be recorded.

(3) All products shall be delivered with inspection certificates 3.1 according to DIN EN 10204:2005-01.

2.2.2.2 Fasteners

(1) For CE-marking of bolts according to DIN EN ISO 3506-1:2010-04 and nuts according to DIN EN ISO 3506-2:2010-04 DIN EN 15048-1:2007-07, Annex ZA applies.

Bolts and nuts not included in DIN EN ISO 3506-1 or -2:2010-04 (e. g. > M39) as well as other threaded parts, the package or the enclosed leaflet shall be marked by the manufacturer with the conformity mark Ü (Ü-mark) in accordance with the decrees on conformity marking of the States of the Federal Republic of Germany. The name of the manufacturer and the number of this national technical approval shall be declared in the conformity mark. Marking is only allowed if the conditions given in section 2.3 are satisfied. Furthermore the fasteners shall be marked with the steel name or steel number according to the delivery conditions in section 2.1.2 and 2.1.3 of this national technical approval. The bolts, nuts and threaded parts shall be marked according to Table 2 in the basis of DIN EN ISO 3506-1 and -2:2010-04.

(2) The fasteners shall be delivered with an inspection certificate 3.1 according to DIN EN 10204:2005-01.

2.3 Verification of conformity

2.3.1 General

(1) The following provisions of Section 2.3 apply to the products and fasteners marked with the mark of conformity (*Ü-Zeichen*) ('Ü-mark') according to Section 2.2.2.

(2) Proof of conformity of the products and fasteners made of stainless steels manufactured according to this national technical approval, with the provisions of this national technical approval, shall be delivered by means of a certificate of conformity issued for each manufacturing plant and based on factory production control and continuous surveillance including initial-type testing of the construction product in accordance with the following provisions.

(3) The manufacturer of the products and / or fasteners shall involve an accredited certification body and an accredited monitoring body for the issuing of the certificate of conformity and for the outside monitoring, including the related product inspections.

(4) The declaration that a certificate of conformity has been granted shall be given by the manufacturer by marking the construction products with the mark of conformity (*Ü-Zeichen*) ('Ü-mark') stating the intended use.

(5) The certification body shall submit, for information, a copy of the relevant certificate of conformity to the *Deutsches Institut für Bautechnik*. Additional a copy of the initial type testing report shall be submitted to the *Deutsches Institut für Bautechnik* for information.

2.3.2 Factory production control

(1) Every manufacturing plant shall have a factory production control system and exercise factory production control. Factory production control means the permanent control of production exercised by the manufacturer by which the latter ensures that the products and fasteners produced by him are in conformity with this national technical approval.

(2) For the tests, the range of tests as well as for taking of samples the technical delivery conditions for products of corrosion resisting steels according to Section 2.1.2 of this national technical approval apply. For bolts, threaded bars, nuts and washers DIN EN ISO 3269:2000-11 in conjunction with DIN EN ISO 3506-1:2010-04 and DIN EN ISO 3506-2:2010-04applies.

A tightness test (inside pressure test according to DIN EN 10296-2:2006-02 and DIN EN 10297-2:2006-02) may be omitted for pipes

(3) The results of factory production control shall be recorded and evaluated. The records shall include at least the following information:

- designation of the construction product or the initial materials and the components
- type of control,
- date of manufacture and date of testing of the construction product or the initial materials and the components,
- results of control and and as far as it applies comparison with requirements,
- signature of the person responsible for factory production control.

(4) The records shall be kept for at least five years and shall be presented to the inspection body involved in surveillance. On request, they shall be presented to the *Deutsches Institut für Bautechnik* and to the relevant supreme building authority.

In case of unsatisfactory test results the manufacturer shall immediately take the measures necessary to rectifying the fault. Construction products not meeting the requirements shall be handled in a way that confusion with the products in compliance with the specifications will be excluded. As soon as the fault has been rectified - as far as technically possible and required for evidence that the fault has been rectified - the corresponding test shall be repeated immediately.

2.3.3 Surveillance

(1) Factory production control exercised in every manufacturing plant shall be continuously verified by surveillance, but at least once a year.

In the framework of surveillance, an initial-type testing of the construction product shall be performed and also samples can be taken for audit-testing. Sampling and testing are in the responsibility of the approved body.

(2) In the framework of surveillance the following tests shall be executed on the products released for delivery:

- at least 3 tensile tests at ambient temperature,
- for the steel grades 1.4003, 1.4016, 1.4362 and 1.4462 at least one set (3 samples) charpy tests at longitudinal specimen,

- visual testing of surface conditions,
- check of geometry,
- product analyses.

(3) For fasteners DIN EN ISO 3269:2000-11 applies in connection with DIN EN ISO 3506-1 and -2:2010-04.

(4) Further details shall be taken from the technical delivery conditions in accordance with Section 2.1.2 and 2.1.3

(5) The results of the certification and surveillance shall be kept for at least five years. On request, it shall be presented by the certification body or inspection body to the *Deutsches Institut für Bautechnik* and to the relevant supreme building authority.

3 Provisions for the design and calculation of structural parts and joints

3.1 General

3.1.1 Technical rules to be applied

DIN 18800-1 to 4:2008-11 and the engineering standards mentioned in section 1.2 applies and also, as far as this concerns engineering standards, the ATP Directive for steel construction with modification and supplement - edition December 2001, as far as no other definitions are stated following behind. The regulations concerning the construction and design in section 4 of this national technical approval are to be taken into account as wells.

3.1.2 Different steel grades in a supporting structure

Deviating from DIN 18800-1:2008-11, element 502 shall be taken into account:

If different steel grades are used in a supporting structure, the different coefficients of thermal expansion shall be considered. This applies for temperature changes due to working process or weather as well as for such that occur during fabrication through welding and in the event of fire for example.

3.2 Design

3.2.1 Bolted connections

(1) Friction grip connections according to DIN 18800-1:2008-11, element 506, are not subject of this national technical approval.

(2) Owing to possible creep phenomena with tensile loads, the planned pre-stress may not be utilized also with regard to the serviceability.

(3) With regard to corrosion protection for bolt spacings according to line 5 required in DIN 18800-1:2008-11, Table 7, footnote, supplementary to element 513 applies: The corrosion protection assumed for the enlargement of the edge distances and hole spacings indicated in line 5 of Table 7 of DIN 18800-1:2008-11 is given for the steel grades according to this national technical approval if the requirements are met according to section 2.1.6.

(4) If welding is envisaged on fasteners, they are basically classified into property class 50.

3.2.2 Welded joints

3.2.2.1 Limitation of weld thicknesses

(1) For welded joints of components made of austenitic steels with those made of ferritic steels, the weld thickness may be not more than 16 mm unless the qualification for the bigger values has not been proven by an earlier production control test according to DIN EN ISO 15613.

(2) Supplementary to DIN 18800-1:2008-11, Element 519, applies: For cross-section parts with thicknesses of 1.5 mm $\leq t <$ 2 mm, the fillet weld thickness a = min t should be selected.

3.2.2.2 Welding in cold-formed areas

(1) Welding in cold-formed areas is admissible taking into account section 4.3. Deviating from DIN 18800-1:2008-11, Element 522, the regulations according to DIN 18800-1:2008-11, Table 9 does not apply.

(2) Regarding the ferritic steel grade with the material number 1.4003 cold forming of maximum 5 % is admissible for welded components, since with a higher cold forming and an additional heating, a grain growth with loss of ductility may occur.

3.3 Structural design

3.3.1 Characteristic values of mechanical properties for proofs of structural safety and serviceability

3.3.1.1 Steel grades of the products according to Annex 1, Table 1

(1) For calculations according to the theory of first order, the characteristic values according to Appendices 8.1 and 8.2, Table 11 apply.

(2) For calculations according to the theory of second order and other proofs of stability according to DIN 18800-2 to -4:2008-11, the values according to Annex 8.1 and 8.2 Table 11, column 3 apply. For cold-worked states of the steel grades

- 1.4003, 1.4016, 1.4567, 1.4318, 1.4578, 1.4439, 1.4362, 1.4539, 1.4565, 1.4529 and 1.4547, however, only the characteristic values $f_{y,k}$ indicated in column 3 of Table 11 for the annealed materials,
- 1.4301, 1.4307, 1.4401, 1.4404, 1.4541, 1.4571 and 1.4462 only the characteristic values $f_{y,k}$ of the lower strength class next to the specified strength class indicated in column 3 of Table 11, but not more than 355N/mm² shall be set, unless higher values are verified and granted through a product related approval test. The latter applies for welded hollow sections of Stala Tube Oy, Lahti, Finland. For the cold-worked states of the steel grades,
- 1.4301, 1.4571 up to strength class S460,
- 1.4318 strength class S355 only

the characteristic values of the yield strength can be set for them even for the proof of stability without any reduction.

(3) For the modulus of elasticity E, the values according to Table 11, column 6 are to be set as characteristic values, unless the load is not determined through restraints. For the calculation of constraint stresses, the values according to Table 11, column 7 apply.

3.3.1.2 Materials of the fasteners according to Annex 2, Table 2.

The characteristic values according to Annex 9, Table 12 apply. If welding is envisaged on fasteners, the values of strength class 50 are to be always used for the design.

3.3.2 Stress strain relations

3.3.2.1 General

(1) Also far below the yield strength $R_{p0.2}$, the strains ε depend non-linearly on the stresses (Fig. 1a in Annex 14). They can be specified through the power law

$$\varepsilon = \frac{\sigma}{E} + 0{,}002 \cdot \left[\frac{\sigma}{f_{y,k}}\right]^n$$

with

$n = 6$	for	$\sigma \le f_{y,k}$
$n = 17$	for	$\sigma > f_{y,k}$
$f_{y,k}$	according to 3.3.1.1(1) or 3.3.1.1(2)	
E	according to 3.3.1.1(3)	

(2) Instead of this non-linear stress strain relation according to paragraph 1, the proofs may be based upon a linear elastic perfect plastic stress strain relation according to the sections 3.3.2.2 or 3.3.2.3.2.

3.3.2.2 Stress-strain relation for proofs according to the theory of first order.

For calculations according to the theory of first order, the linear elastic perfect plastic stress-strain relation according to Fig. 1b in Annex 14 may be arranged.

3.3.2.3 Stress and strain relation for proofs according to the theory of second order.

3.3.2.3.1 General

For calculations according to the theory of second order, the hardening range of the stress-strain relation shall not be used. This means that the power law is restricted to

$$\varepsilon = \frac{\sigma}{E} + 0{,}002 \cdot \left[\frac{\sigma}{f_{y,k}}\right]^n$$

with

$n = 6$ for $\sigma \le f_{y,d}$

and for

$$\varepsilon > \frac{f_{y,d}}{E} + 0{,}002 \cdot \left[\frac{f_{y,d}}{f_{y,k}}\right]^n$$

$\sigma = f_{y,d}$ applies.

3.3.2.3.2 Linearization of the strain-stress relation

(1) For calculations according to the theory of second order, instead of a stress-strain relation according to 3.3.2.3.1, a linear-elastic perfect plastic stress-strain may be assumed either

- according to Fig. 1c in Annex 14 with a non-reduced yield strength $f_{y,k}$ and the secant modulus $E_{sek,y}$ or
- according to Fig. 1d in Annex 14, assumed with a reduced yield strength red $f_{y,k}$ and the corresponding secant modulus E_{sek}. For red $f_{y,k}$, E_{sek} and $E_{sek,y}$ applies:

  red $f_{y,k} = \rho_f \cdot f_{y,k}$

$$E_{sek} = \frac{E}{1 + 0{,}002 \cdot \frac{E}{f_{y,k}} \cdot \rho_f^5} \quad \text{and} \quad E_{sek,y} = \frac{E}{1 + 0{,}002 \cdot \frac{E}{f_{y,k}}}$$

with

ρ_f yield strength reduction factor

red $f_{y,k}$ and E_{sek} are to be calculated with the same yield strength reduction factor ρ_f. Subject to the conditions

$$\rho_f = \frac{\text{red } f_{y,k}}{f_{y,k}}$$

$$\sigma_v \le \rho_f \cdot \frac{f_{y,k}}{\gamma_M}$$

with

σ_v effective stress according to DIN 18800-1:2008-11, eq. (36) may be freely selected.

For $\rho_f \leq 0.40$, the value E according to Table 11, column 6 may be arranged for E_{sek}.

Note 1:

The second condition corresponds to the proof according to DIN 18800-2:2008-11, element 121. Accordingly, it is to be proven that the effective stress is not bigger than the design value of the reduced yield strength.

Note 2:

For $\rho_f = 1$, the stress-strain relation according to Fig. 1c in Annex 14 is obtained as a special case

red $f_{y,k} = f_{y,k}$ and $E_{sek} = E_{sek,y}$

applies.

Note 3:

Remark on the determination of the yield strength reduction factor ρ_f

- If the effective strength σ_v is known, then ρ_f follows from:

$$\rho_f = \sigma_v \cdot \frac{\gamma_M}{f_{y,k}}$$

- If the effective strength σ_v is still unknown, ρ_f shall be estimated at first. The suitable selection of ρ_f depends on the slenderness ratio of the component to be investigated. It is advisable to select $\rho_f = 1$ for compact components, $\rho_f = 0.4$ for very slender components, and ρ_f between 0.5 and 0.9 for slender to medium slender components. In order to obtain the mathematically biggest stress, ρ_f shall be varied.

(2) For all secant moduli E_{sek} the corresponding shear modulus is defined with

$$G_{sek} = \frac{E_{sek}}{2(1+\mu)}$$

and

$$\mu = 0.3$$

3.3.2.3.3 Design values of the variables E_{sek}, G_{sek} and red $f_{y,k}$

With regard to the variables E_{sek}, G_{sek} and red $f_{y,k}$ or in the special case according to Fig.1c in Annex 14, the variables $E_{sek,y}$ and $G_{sek,y}$ are characteristic values in terms of DIN 18800-1:2008-11, Element 304.

The design value of the reduced yield strength is

$$\text{red } f_{y,d} = \frac{\text{red} \cdot f_{y,k}}{\gamma_M} = \frac{\rho_f \cdot f_{y,k}}{\gamma_M}$$

If a secant modulus $E_{sek} > E_{sek,y}$ is assumed, thus $\rho_f < 1$, for the stress-strain relations, all proofs shall be furnished with red $f_{y,d}$.

3.3.3 Delimitation criteria

For proofs according to DIN 18800-1:2008-11, elements 728, 739 and 740, the secant modulus $E_{sek,y}$ according to 3.3.2.3.2(1) shall be applied instead of the E-modulus.

This also applies for calculating deformations and buckling loads used.

3.3.4 Service strength

The conditions (25) and (26) in DIN 18800-1:2008-11 are to be substituted by:

$\Delta\sigma$ < 21 N/mm² for (25)

n < 10^7 $(21/\Delta\sigma)^3$ for (26)

3.3.5 Proofs according to DIN 18800-1:2008-11

3.3.5.1 Force applications

The limit force $F_{R,d}$ according to DIN 18800-1:2008-11, element 744, is to be reduced to 74 % of the values determined according to the equations (29) and (30).

The maximum value 60 indicated in element 744 regarding the web slenderness h/s, for which safety against buckling does not have to be proven, is to be substituted by 32.

3.3.5.2 Hole weakening

The proof is to be furnished independent on the bearing stress proof element (805) in DIN 18800-1:2008-11. The proof whether the deduction of holes may be disregarded, shall be furnished using equation (27) in element 742.

3.3.5.3 Limiting values limit (b/t) and limit (d/t) according to Tables 12 to 14 in DIN 18800-1:2008-11

When applying DIN 18800-1:2008-11, element 745, with Tables 12 to 14, the quotient

$$\frac{240}{\sigma_1 \cdot \gamma_M} \quad \text{shall be substituted by} \quad \frac{240}{\sigma_1 \cdot \gamma_M} \cdot \frac{E_{sek}}{E_{Baustahl}}$$

with E_{sek} according to 3.3.2.3.2(1) with $\rho_f = \sigma_1 \cdot \frac{\gamma_M}{f_{y,k}}$

and $E_{Baustahl}$ = 210000 N/mm² (($E_{Baustahl}$ = $E_{carbon\ steel}$))

3.3.5.4 Limiting values limit (b/t) and limit (d/t) according to Table 15 in DIN 18800-1:2008-11

When applying DIN 18800-1:2008-11, element 753, Table 15, the quotient

$$\frac{240}{f_{y,k}} \quad \text{shall be substituted by} \quad \frac{240}{f_{y,k}} \cdot \frac{E_{sek,y}}{E_{Baustahl}}$$

with $E_{sek,y}$ according to 3.3.2.3.2(1),

and $E_{Baustahl}$ = 210000 N/mm²

3.3.5.5 Limiting values limit (b/t) and limit (d/t) according to Table 18 in DIN 18800-1:2008-11

The indications in section 3.3.5.4 regarding DIN 18800-1:2008-11, element 753, Table 15 do also apply for the use of element 758, Table 18.

3.3.5.6 Stress resistance of screws on shear lag

Deviating from element 804 in DIN 18800-1:2008-11, the steel grades with the serial number 3 to 6 and 8 to 11 according to Table 2 apply to α_a in equation (47):

α_a = 0.75 for screws of strength class 50,

α_a = 0.68 for screws of strength class 70 and 80.

The steel grades with the serial number 12 to 17 according to Table 2 apply uniformly to α_a = 0.5 for screws of the strength classes 50, 70 and 80.

The proof shall be always furnished using the stress area A_s independent on the location of the shear plane.

Note:

That has to do with the fact that these screws may show locally different mechanical properties in contrast to screws made of non-alloy or low-alloy steel.

3.3.5.7 Strength capacity of weld joints

(1) Annex 8.1 and 8.2, Table 11 apply to the welding processes 111, 121, 131, 135, 136 and 141, Table 11.

Note: For the remaining welding processes, see 4.6.3 to 4.6.8.

(2) Deviating from DIN 18800-1:2008-11, for the calculation of the limit weld stress regarding weld joints of steels of this national technical approval

- with each other or
- with carbon steels according to DIN 18800-1:2008-11, element 401 or
- with fine-grained steels according to national technical approvals

the smaller value, being the result of this combination from Annex 8.1 and 8.2, Table 11, column 4 and from Annex 5 and 6, Tables 5 to 7 from the columns 4, the smaller value is to be set for $f_{y,k}$. In addition, the proof of load-bearing capacity is to be furnished for the weld joint with the value $f_{y,k}$ of carbon steel or fine-grained steel in case of joints of different steel types according to Table 6 and 7.

3) For the α_w-values, the values of Annex 9, Table 13 of this national technical approval are to be used instead of the values indicated in Table 21 in DIN 18800-1:2008-11. For mixed compounds according to Table 6 and 7, the α_w -value according to Table 21 in DIN 18800-1:2008-11 or according to the corresponding national technical approval is to be applied in the proof of the load-bearing capacity for the weld joint with the values $f_{y,k}$ of carbon steel or fine-grained steel.

(4) DIN 18800-1:2008-11, element 833 with Table 22 shall not be applied.

3.3.6 Proofs according to DIN 18800-2, -3 and -4:2008-11

3.3.6.1 Basics on the proof of safety against instable failure

3.3.6.1.1 Stress-strain relation

For proofs of safety against instable failure, except for simplified proofs in sections 3.3.7 to 3.3.9, in all conditions of DIN 18800-2 and -3:2008-11 corresponding to section 3.3.2.3.2, the following substitutions shall be made:

$f_{y,k}$ through red $f_{y,k}$

$f_{y,k}$ through red $f_{y,k}$

E through E_{sek}

G through G_{sek}

Correspondingly, all factors dependent on these basic parameters are to be marked with the index sek and used in the conditions.

In case of a proof corresponding to section 3.3.2.3.1, with

$$\text{red } f_{y,d} = \max \sigma_v$$

also red $f_{y,k}$, E_{sek} and G_{sek} are defined through the result of the non-linear calculation.

Note:

Examples:

$$N_{ki,sek} = \pi^2 \cdot \frac{(EI)_{sek}}{s_k^2}$$

$$N_{pl,sek,d} = \text{red } f_{y,d} \cdot A$$

$$\varepsilon_{sek} = l \cdot \sqrt{\frac{N}{(EI)_{sek}}}$$

$$\lambda_{a,sek} = \pi \cdot \sqrt{\frac{E_{sek}}{red \quad f_{y,k}}}$$

$$\sigma_{e,sek} = \frac{\pi^2 \cdot E_{sek}}{12 \cdot (1-\mu^2)} \cdot \left(\frac{t}{b}\right)^2$$

In the special case red $f_{y,k} = f_{y,k}$ and $E_{sek} = E_{sek,y}$

3.3.6.1.2 Simplified proofs

For the stability cases flexural buckling, lateral torsional buckling and plate buckling, κ-values for stainless steels are indicated in sections 3.3.7 and 3.3.8, which might be also applied to webs that are assumed to be straight with plane thin-walled cross-section parts following the conditions in section 3.3.7.10. In these κ-values, the non-linear material behavior is taken into account.

Therefore, a simplified proof with E = 170000N/mm² and $f_{y,k}$ according to section 3.3.1.1(2) can be furnished in the mentioned cases.

3.3.7 Proofs according to DIN 18800-2:2008-11

3.3.7.1 One-piece members according to DIN 18800-2:2008-11, section 3

The proofs may be furnished according to DIN 18800-2:2008-11, section 3, considering the definition in the following sections 3.3.7.2 to 3.3.7.9 using E = 170000N/mm² and $f_{y,k}$ according to section 3.3.1.1(2), as far as nothing else is defined below.

3.3.7.2 Differentiation towards lateral torsional buckling

Deviating from element 303, the condition according to the 3rd indent is not to be applied here.

3.3.7.3 Reduction factor κ for proofs of flexural buckling

The equations (4a) and (4b) in element 304 are to be substituted by:

$\bar{\lambda}_K \le 0{,}13$: $\kappa = 1$ for (4a)

$\bar{\lambda}_K > 0{,}13$: $\kappa = \dfrac{1}{k + \sqrt{k^2 - \bar{\lambda}_K^2}}$ for (4b)

$$k = 0.5 \cdot [1 + \alpha \cdot (\bar{\lambda}_K - 0{,}13) + \bar{\lambda}_K^2]$$

Table 4 in element 304 is to be substituted by Table 14 in Annex 10 of this national technical approval.

Note 2 to element 304 is dropped. Figure 10 shall not be used.

3.3.7.4 Additional conditions for changing cross-sections and normal forces

In condition (5) in element 305, the buckling load factor η_{Ki} is to be calculated using $E_{sek,y}$ according to 3.3.2.3.2(1).

3.3.7.5 Impediment of torsion through proof of sufficient torsional restraint

In condition (8) in element 309, it shall be calculated using $E_{sek,y}$ according to 3.3.2.3.2(1) instead of E.

3.3.7.6 Proof of the compression chord as compression member

In (12) and (13), values of red $f_{y,k}$ and E_{sek} assigned to each other are to be used.

$\sqrt{240 / f_{y,k}}$ in condition (15) it is to be multiplied with $\sqrt{E_{sek,y} / E_{Baustahl}}$

where $E_{Baustahl}$ = 210000N/mm² and $E_{sek,y}$ according to 3.3.2.3.2(1)

the reduction factor κ in condition (14) shall be determined according to section 3.3.7.3.

3.3.7.7 Reduction factor κ_M for proofs of lateral torsional buckling

Equation (17) in element 311 may not be used here. Equation (18) applies to all slenderness ratios.

In Figure 14 in element 311, k_n in the right part shall be increased from 0.8 to 0.87.

In element 311, Table 9, the values n in the right column are to be substituted as follows:

Line	n
1	1.17
2	1.03
3	0.89
4	1.03

Line 5 applies with $n = 0.67 + 0.5 \cdot (\min h / \max h)$ deviating from DIN 18800-2:2008-11 for $\min h / \max h \geq 0.5$.

The right side of the condition (21) in Element 311 is to be multiplied with

$$\frac{E_{sek,y}}{E_{Baustahl}}$$

where $E_{Baustahl}$ = 210000 N/mm² and $E_{sek,y}$ according to 3.3.2.3.2(1).

Note 2 regarding element 311 is not to be applied here.

3.3.7.8 Uniaxial bending using normal force

The reduction factors κ and κ_M in the conditions of the elements 312 to 320 are to be calculated according to the sections 3.3.7.3 and 3.3.7.7.

In equation (23) in element 313,

$\alpha \cdot (\bar{\lambda}_k - 0{,}2)$ shall be substituted by

$\alpha \cdot (\bar{\lambda}_k - 0{,}13)$

In condition (24) $M_{pl,d}$ shall be substituted by $\rho_f \cdot M_{pl,d}$,and $\Delta n / \rho_f$ is to be inserted instead of Δn. The additional condition $\Delta n \leq 0.1$ does not apply for $\Delta n / \rho_f$. As an approximation on the safe side, that value may be inserted for ρ_f, ensuing for the related slenderness $\bar{\lambda}_k$ for which the reduction factor κ was determined. The values ρ_f indicated in the Tables of Appendices 14.1 to 14.4 are on the safe side.

In condition (26) in element 318, the buckling load factor η_{ki} with $E_{sek,y}$ is to be calculated according to 3.3.2.3.2(1).

In condition (27) in Element 320, $k_y = 1$ is to be substituted.

3.3.7.9 Two-axial bending with or without normal force

Simplified proofs with the conditions (28) in element 321 and (29) in Element 322 shall not be furnished.

Proofs with the condition (30) in element 323 may be furnished with

$k_y = 1$ and $k_z = 1.5$

if the reduction factors κ and κ_M are calculated according to the sections 3.3.7.3 and 3.3.7.7 and $M_{pl,z,d}$ is substituted by $\rho_f^+ \cdot M_{pl,z,d}$. As a cautious approximation, the smaller of the two values ρ_f may be inserted for ρ_f^+ ensuing from the related slendernesses $\bar{\lambda}_K$ and $\bar{\lambda}_M$ for which the reduction factors κ and κ_M were determined. The values ρ_f for lateral torsional buckling indicated in the Tables of Appendices 14.1 to 14.4 are on the safe side. The values for lateral torsional buckling can be taken from the Tables of Annex 15.

3.3.7.10 Regular straight members with plane thin-walled cross-section parts

3.3.7.10.1 General

The regulations in DIN 18800-2:2008-11, section 7, may be basically used as simplified proofs according to section 3.3.6.1.2 with due regard to the changes mentioned in sections 3.3.7.10.2 to 3.3.7.10.9.

3.3.7.10.2 Application range

Regarding the note in element 701, section 3.3.5.3 shall be taken into account.

3.3.7.10.3 Verification procedure

Deviating from element 702, the proof of structural safety may be only furnished according to the procedure elastic-elastic. The conditions in the elements 705 to 729 belonging to the verification procedure elastic-plastic may not be used.

3.3.7.10.4 Influence on shear stresses

In element 703, condition (80), the ideal plate buckling stress $\tau_{Pi,d}$ is to be calculated with $E_{sek,y}$ according to 3.3.2.3.2(1).

3.3.7.10.5 Effective width for the procedure elastic-elastic

Corresponding to the conditions of the elements 711 to 713, the effective width b' is to be determined with the changes mentioned below.

The limit case $\sigma = f_{y,d}$ mentioned in note 2 regarding element 712 is to be assumed. Consequently, $\bar{\lambda}_P$ is written instead of $\bar{\lambda}_{P\sigma}$.

$$b' = 0.74 \cdot \left\{ \frac{1}{\bar{\lambda}_P} - \frac{0.22}{\bar{\lambda}_P^2} \right\} \cdot b \qquad \text{for} \qquad \bar{\lambda}_P > 0.673 \cdot \sqrt{\frac{E_{sek,y}}{E}}$$

Effective width with bearing on one side:

$$b' = b \qquad \text{for} \qquad \lambda_p \le 0.7 \cdot \sqrt{\frac{E_{sek,y}}{E}}$$

$$b' = \left\{ \frac{0.68}{\bar{\lambda}_P} - \frac{0.11}{\bar{\lambda}_P^2} \right\} \cdot b \qquad \text{for} \qquad 0.7 \cdot \sqrt{\frac{E_{sek,y}}{E}} < \bar{\lambda} < 0.6875$$

$$b' = \frac{0.52}{\bar{\lambda}_P} \cdot b \qquad \text{for} \qquad \bar{\lambda}_p \ge 0.6875$$

with $E_{sek,y}$ = secant modulus according to 3.3.2.3.2(1),

E = modulus of elasticity according to Annex 8.1 and 8.2, Table 11, column 6.

Deviating from the factors defined in DIN 18800-2:2008-11, element 712, these are:

$$\bar{\lambda}_p = \sqrt{\frac{f_{y,k}}{k \cdot \sigma_e}}$$

$$\sigma_e = 153\,600 \cdot \left(\frac{t}{b}\right)^2 \text{N/mm}^2$$

In Table 27, line 1, the effective widths are to be determined as follows:

$b'_1 = 0.74 \cdot \rho \cdot b \cdot k_1$

$b'_2 = 0.74 \cdot \rho \cdot b \cdot k_2$

3.3.7.10.6 Simplified proof for regular axial compression

In element 716, in equation (91)

$\alpha' \cdot (\bar{\lambda}'_k - 0.2)$ shall be substituted by $\alpha' \cdot (\bar{\lambda}'_k - 0.13)$

and the parameters α in equation (92) are to taken from Table 14 in section 3.3.7.3.

3.3.7.10.7 Two-axial bending with and without normal force

The simplified proof of the load-bearing capacity according to element 721 shall not be furnished.

3.3.7.10.8 Proof of the compression chord as compression member

With regard to the conditions in element 724, section 3.3.7.6 is to be taken into account.

3.3.7.10.9 General proof

In DIN 18800-2:2008-11, element 725, $\sigma_e = 153600 \cdot \left(\frac{t}{b}\right)^2$ N/mm² is to be inserted.

3.3.8 Proofs according to DIN 18800-3:2008-11

3.3.8.1 General

DIN 18800-3:2008-11 may be applied for the proof of safety against buckling with regard to unstiffened plates, where the definitions in sections 3.3.9.2 to 3.3.9.5 as well as Table 15 in Annex 11 apply.

3.3.8.2 Parameters

(1) Deviating from DIN 18800-3:2008-11, element 113, note 2, with E = 170000 N/mm² and $\mu = 0.3$

$$\sigma_e = 153\,600 \cdot \left(\frac{t}{b}\right)^2 \text{N/mm}^2$$

applies.

(2) The numerical data in DIN 18800-3:2008-11, element 113, note 4, for the reference slenderness ratio λ_a do not apply for stainless steels. In the individual case, they are to be calculated with the characteristic values according to 3.3.1.1(2) and 3.3.1.1(3).

3.3.8.3 Components without or with simplified proof

(1) The indications for rolled steel sections (I, U, HE-A, HE-B, HE-M and IPE) in DIN 18800-3:2008-11, element 202, do not apply for stainless steels.

(2) The elements 203 and 204 are not to be used.

(3) In the condition for b_{ik}/t in element 205, E is to be substituted by $E_{sek,y}$ behind the second en dash.

3.3.8.4 Critical local buckling stresses with buckling effect

In DIN 18800-3:2008-11, element 503, for the reduction factor for buckling κ_K, the value according to section 3.3.7.3 of this national technical approval is to be used instead of that according to DIN 18800-2:2008-11, element 304.

3.3.8.5 Reduction factors κ

(1) The reduction factors according to Annex 11, Table 15 are to be used instead of those according to DIN 18800-3:2008-11, Table 1 and Figure 9.

(2) In element 603, equation (24), for the reduction factor for buckling κ_K, the value according to section 3.3.7.3 of this national technical approval is to be used instead of that according to DIN 18800-2:2008-11, element 304.

3.3.9 Proofs according to DIN 18800-4:2008-11

3.3.9.1 Delimitation criteria

In the condition indicating when no proof is necessary, $E_{sek,y}$ according to 3.3.2.3.2(1) is to be used instead of the E-modulus. This concerns the following conditions for the cylindrical shell

- (32) in element 411 for compressive stress in circumferential direction,
- (37) in element 415 for shear load,

and for the rounded washer it concerns the condition

- (80) in element 704.

For the condition (25) in element 405 regarding compressive stress of the cylindrical shell in axial direction, the E-modulus may be used according to Annex 8.1 and 8.2, Table 11, column 6.

Condition (31) that excludes the proof of safety against buckling for very long circular cylinders given in element 410, does not apply for stainless steels.

3.3.9.2 Simplified proofs for very slender shells

If with

E according to Annex 8.1 and 8.2, Table 11, column 6 and

$f_{y,k}$ according to section 3.3.1.1(2)

for normal imperfection sensitive cases of shell buckling

$$\overline{\lambda_s} \geq 1{,}90$$

ensues, the proof may be furnished with 0.4 $f_{y,k}$ instead of $f_{y,k}$ and E (see also Annex 13).

3.3.9.3 General proof

If for a case of shell buckling, the related slenderness ratio does not fulfill the condition to be applied according to section 3.9.1 and 3.3.9.2, the proofs are in general to be furnished alternatively using one of the two linearized stress-strain relations according to section 3.3.2.3.2. Furthermore, for the proof of safety against buckling, the definitions in sections 3.3.1.1, 3.3.2.3.2 and 3.3.2.3.3 apply for determining the material parameters.

Note: The characteristic values of the real buckling stresses $\sigma_{S,R,k}$ according to equations 4 and 5 of DIN 18800-4:2008-11 determined with the linearized stress-strain relation according to Figure 1d correspondent to the mentioned sections, are indicated in Annex 13 with E = 170000N/mm² for the general case.

3.3.9.4 Proof for the cylindrical shell with compressive stress in axial direction

The proof may be furnished according to DIN 18800-4:2008-11 with E correspondent to Annex 8.1 and 8.2, Table 11, column 6 and $f_{y,k}$ according to section 3.3.1.1(2), if the characteristic values of the real buckling stresses determined in this way are reduced by the factor Ψ dependent on the shell slenderness to the value

$$\sigma_{xS,R,k} = \Psi \, \kappa_2 \, f_{y,k}$$

where for

$\Psi = 1$ for $\overline{\lambda}_S \leq 0{,}40$

$\Psi = 1 - 0.735\left(\overline{\lambda}_S - 0{,}40\right)$ for $0{,}40 \leq \overline{\lambda}_S \leq 0{,}74$

$\Psi = 0.75$ for $0{,}74 \leq \overline{\lambda}_S \leq 1{,}00$

$\Psi = 0.75 + 0.658\left(\overline{\lambda}_S - 1\right)$ for $1{,}00 \leq \overline{\lambda}_S \leq 1{,}38$

$\Psi = 1$ for $1{,}38 \leq \overline{\lambda}_S$

applies.

3.3.10 Proofs according to DIN 18808:1984-10 (structures made of hollow sections)

3.3.10.1 General

(1) Components consisting of hollow sections made of stainless steels of strength classes S460 and S690 are not subject of this national technical approval.

(2) For the proof of the load-bearing capacity for structures made of welded hollow sections DIN 18808:1984-10 applies, including the parts of the part of the *Anpassungsrichtlinie Stahlbau* ('adjustment directive for steel structures') with the following deviations:

3.3.10.2 Limits and regulations for member dimensions in trusses

Deviating from Table 3 of the standard, Table 16 in Annex12 of this national technical approval applies.

3.3.10.3 Proof of the wall thickness for unstiffened truss joints

3.3.10.3.1 Application of Figures 3 to 8

The values erf (t_u/t_a) may be taken from Figure 3 to 8, if they are equalized for stainless steels in the strength classes S235 and S275 to those indicated for "steel S235 (St 37)", and for the strength class S335 to those indicated for "steel S355 (St 52)".

On the right and on the left, the ordinate scale is equal independent on the strength class, and is as follows:

$$(\text{vorh } \sigma_{u,Druck} / \text{limit } \sigma),$$

where the numerical values start with 0.143 at the bottom and end with 1.00 at the top.

3.3.10.4 Torsionally rigid stiff-jointed frameworks made of rectangular hollow sections

3.3.10.4.1 Limits and regulations of web dimensions for torsionally rigid stiff-jointed frameworks with

$$\vartheta = 90°$$

Deviating from Table 5 of the standard, Table 17 in Annex 12 of this national technical approval applies.

3.3.10.4.2 Proof of the load-bearing capacity for weld joints.

Deviating from section 5.5 of the standard, the following applies:

$\alpha \leq 0.71$ for steel grade 1 according to Annex 1, Table 1,

$\alpha \leq 0.84$ for steel grades 3, 4, 6, 8, 9, 11, 12, 13 and 16 according to Table 1.

3.3.11 Proof of the fatigue strength of façade elements

(1) For components, anchorage means and fasteners that are outside of thermal insulation of a building, except for the cases mentioned in paragraph (2), temperature related plastic deformations may only be acknowledged if a sufficient fatigue resistance is verified through tests and a corresponding expert´s report of an inspection body experienced in this field. A copy of the test report and the expert´s report is to be submitted to the attention of the *Deutsches Institut für Bautechnik* (DIBt).

The parts are to be investigated in a test using amplitude corresponding to thermal expansion.

For a pulsating stress, the following load spectrum is to be arranged:

100 load cycles for a displacement corresponding to $\Delta T = 70K$,

2000 load cycles for a displacement corresponding to $\Delta T = 60K$,

20000 load cycles for a displacement corresponding to $\Delta T = 50K$.

Subsequent to this load spectrum, loads shall be reached in the static test ensuring that at least 80 % of the static load-bearing capacity is still available without fatigue load.

During the test no remaining deformation shall occur under the characteristic impact.

(2) With a maximum stress of $\alpha_k \cdot \sigma \leq 225$ N/mm² under service load, a proof of fatigue resistance through tests is unnecessary for temperature related pulsating stress, where α_k shall be inserted into the formula corresponding to the notch radius (for ex. for screw threads according to DIN 13-1:1999-11 $\alpha_k = 4{,}0$). In this case, a proof of the load-bearing capacity under predominantly static load is sufficient.

3.3.12 Fire protection

For stainless steels through strength class S355, the fire behavior may be assessed such as for non-alloy carbon steels according to DIN 4102-4:1994-03. For higher strength classes, critical temperatures apply as presented in DIN 4102-4:1994-03, Figure 68. Therefore, the components made of this steel shall also be classified for fire resistance.

4 Provisions for execution of the structural parts

4.1 General

DIN 18800-7:2008-11 applies, unless otherwise stated below.

4.2 Suitability for cutting

All steels of this national technical approval may be machined, mechanically or thermally cut or separated. Flame cutting with oxy-acetylene burner is not possible for stainless steels. When stipulating the operation parameters for machining, such as for e.g. geometry of the cutting tools, cutting speed and feed rate, the structure of the respective steel grade shall be taken into account according to Annex 1, Table 1.

Oxide coatings or tarnish films developed during thermal cutting processes shall be removed according to the requirements of corrosion protection (cf. section 2.1.6.3).

The depth of softening measured from the cutting surface is maximum:

- For austenitic steels 1.5 mm,
- For austenitic-ferritic steels 2.0 mm,
- for ferritic steels 3.0 mm.

These softening zones shall be taken into account for the proof of the load-bearing capacity when they comprise more than 10% the load-bearing cross sectional area.

If smaller softening zones are arranged for the calculation when applying other thermal cutting processes such as laser beam or electron-beam cutting processes, they shall be proven by tests.

4.3 Thermal treatment

Thermal treatments of ferritic steels can become necessary after cold forming, see section 4.4.

Thermal treatments of austenitic and austenitic-ferritic steels through convertors are unallowable, excepting in single cases after hot forming, see section 4.5.

4.4 Cold forming

During cold forming of components no cracks shall occur.

As a reference value for the minimum bending radius r regarding flat products up to a thickness of 3 mm, the following applies to steel grades in annealed state:

- for austenitic steels r = 0
- for ferritic-austenitic as well as for ferritic steels r = t

In addition, during cold forming through chamfering of sheet and strip as well as for bending of flat bars and rods, the following applies to the minimum radius r

$$r = (4.2 - A_5/10) \cdot t$$

with

r = inside radius

A_5 = minimum elongation at fracture in % for annealed states according to the technical delivery condition and for cold-worked steels according to Annex 3, Table 3, where for values bigger than 42, the value 42 shall be inserted

t = plate thickness or diameter of rods

If the parameters of elongation at fracture A_5 are lower in transverse direction, this shall be taken into account when chamfering in transverse direction using these vales in the equation above.

4.5 Hot forming

If in the single case, hot forming is necessary, the conditions shall be determined through tests. The test results shall be recorded in the manufacturing book.

4.6 Performance of welding work

4.6.1 General

(1) Welding manufacturers shall possess a manufacturer qualification corresponding to the fabrication, see section 4.7. Welding work shall be performed according to current welding instructions.

(2) During welding, the higher thermal expansion of the austenitic steels and the lower thermal conductivity of all steels according to Table 1 shall be taken into account compared to low-alloy and non-alloy carbon steels.

(3) For drawn arc stud welding, stud welding with tip ignition, resistance spot welding, resistance flash welding, resistance butt welding or upset welding and for friction welding component-specific production control tests shall be performed before the production is resumed after a longer process interruption (more than 6 months). Also during continuous fabrication, at least once a year such production control tests are necessary. The results of these production control tests as well as possibly additional routine manufacturing tests shall be recorded in a manufacturing book that shall be available in the workplace and shall be submitted on demand to the approved body for insight and examination.

(4) Provided an expert report of an approved body is required, the approved body shall provide a copy of this expert report to the *Deutsches Institut für Bautechnik* for information.

4.6.2 Arc welding (111, 121, 131, 135, 136, 141)

(1) With the exception of the steel grades with the material numbers 1.4301, 1.4307, 1.4541, 1.4401, 1.4404, 1.4571 in the strength class S235 as well as joints of these steel with non-alloy carbon steels and joints of these materials among each other, procedure tests according to DIN EN ISO 15614-1:2000-08 shall be performed before starting production.

(2) For reasons mentioned in section 4.6.1 (2), the root gap for austenitic steels shall be kept about 40% bigger compared to low-alloy and non-alloy carbon steels.

(3) With regard to the avoidance of hot cracks and the limitation of dropping in strength for cold-worked steels, the energy per unit length shall be possibly kept low. For the steel grades with the material numbers 1.4003, 1.4539, 1.4439, 1.4529 and 1.4565 as well as for all strained hardened steel grades 15 kJ/cm shall not be exceeded.

(4) In addition, DIN EN 1011-3:2001-01 shall be taken into account.

4.6.3 Resistance spot welding (21)

An expert report of an approved body is necessary in which the stress resistance is defined.

4.6.4 Flash welding (24) and upset welding (25)

Only approximately equal cross-section may be connected to each other. An expert report of an approved body is necessary, in which indications on the welding quality requirements and the stress resistance are defined.

4.6.5 Stud welding (78)

(1) The welding units shall be suitable for welding of stainless steel grades. Stud welding is limited to the steel grades with the material numbers 1.4301, 1.4307, 1.4401, 1.4404, 1.4541, 1.4571, 1.4362, 1.4462, 1.4439 as well as mixed joints with these steels. For stud shape and stud materials DIN EN ISO 13918:2008-10 additionally applies.

(2) Different materials according to section 2.1.4.2 may be welded. For black and white joints, the combination white stud - black supporting structure is approved. The following conditions shall be kept:

- white stud diameter ≤ 12 mm,
- stud welding with shielding gas or ceramic ring,
- when using a ceramic ring, studs shall have an aluminum addition at the welding nozzle.
- the original corrosion protection of the black supporting structure shall be restored and embed the welding bead.

4.6.6 Friction welding (42)

(1) The welding plant shall be suitable for welding of components made of stainless steels (for. ex. machine size and clamping technology) and shall be able to record welding data continuously, e.g. having a parameter monitoring.

(2) An expert report of an approved body is necessary in which the welding technology quality requirements and the stress resistance are defined.

4.6.7 Laser beam welding (52)

(1) At present, laser beam welding comes into consideration for the steel grades with the material numbers .4301, 1.4307, 1.4541, 1.4401, 1.4404 and 1.4571. Here, the application is limited to the utilization of the strength class S235 and welding depths ≤ 12 mm. Black-white joints shall not be produced using this method.

(2) Only strength class S235 shall be applied for the stress resistances.

4.6.8 Electron beam welding (51)

(1) At present, electron beam welding for butt welds comes into consideration for the steel grades with the material numbers .4301, 1.4307, 1.4541, 1.4401, 1.4404 and 1.4571. Here, the application is restricted to wall thicknesses up to 20 mm. Black-white joint shall not be produced using this method.

(2) An expert report of an approved body is necessary, in which the welding technology quality requirements and the stress resistance are defined. Only strength class S235 shall be applied for the stress resistances.

4.6.9 Flame-straightening

(1) Flame straightening of components made of stainless steels should be avoided. If it is inevitable, the maximum temperatures shall be kept as low as possible, and the soak times as short as possible. In addition, the following items shall be taken into account:

(2) The surface shall be free from sulfurous agents and other impurities such as labeling iron dust and grease.

(3) The acetylene oxygen flame shall be adjusted neutrally or slightly oxygen-excessive, by no means gas-excessive.

(4) The thermal exposure time (preheating + time at temperature + cooling off time) should be as short as possible. Cooling off shall be done using water or compressed air.

(5) The following conditions shall be kept:

Steel grade	Temperature of flame straightening*	Radiant heat color
Austenitic steels	650 ℃ - 750 ℃	Brown-red to dark red
1.4003 1.4362 1.4462	500 ℃ - 600 ℃	Blue-grey until start dark red
* time at temperature max. 12 minutes for austenitic steels, max. 8 minutes for 1.4362 and 1.4462 as well as 4 minutes for 1.4003		

(6) Arresters or striking tools as well as other tools should consist of CrNi-steel or should be chrome-plated.

(7) After straightening, discolorations, oxide inclusions and forge scales shall be completely removed through suitable measures. Flame straightening shall only be performed by trained staff in accordance with the welding supervisor.

(8) In case of cold-worked steels, softening due to flame straightening shall be taken into consideration for the proofs of the load-bearing capacity. This can simply come about in such a way that the strength parameters of the steel are assessed for the annealed state for the heated zone.

4.7 Requirements on the welding manufacturers

4.7.1 Constructor´s qualification for welding manufacturers

(1) Welding work on structural parts made of stainless steels may only be performed by firms disposing of a valid constructor´s qualification being extended to the application field of stainless steels according to DIN 18800-7:2008-11 of that class resulting from classification features listed below as well as of the type of components and the welding process according to Table 9 to 12 of DIN 18800-7:2008-11. The strength class defined in the structural documents shall be applied as classification feature.

(2) Welding work on components in class A:

Only joints of the same stainless steels with each other are allowable, and the application is restricted to steels with the material numbers 1.4301, 1.4307, 1.4541, 1.4401, 1.4404 and 1.4571 and in the strength class S235.

(3) Welding work on components in class B:

Mixed joints of stainless steels among each other and black-white joints made of non-alloy carbon steels up to and including strength class S275 with stainless steels are allowable, where the application is restricted to stainless steels with the material numbers 1.4301, 1.4307, 1.4541, 1.4401, 1.4404 and 1.4571 in the strength class S235.

Within this strength class S235, no process tests are necessary.

(4) Welding work on components in class C:

Mixed joints of stainless steels among each other, considering strength levels, and

Black-white joints made of non-alloy carbon steels up to and including strength class S275 (with a pure compressive stress up to S355) are allowable with stainless steels, where the application is restricted to stainless steels with the material numbers 1.4301, 1.4307, 1.4541, 1.4401, 1.4404 and 1.4571.

Process test are necessary up to and including strength class S275 (see 4.6.).

(5) Welding work on components in class D and E:

Joints with all material combinations mentioned in this national technical approval may be designed.

Procedure tests are necessary up to and including strength class S275 and all steels not mentioned under (2) (see 4.6).

(6) The provisions in section 13 of DIN 18800-7:2008-11 apply for the issue of the qualifications.

4.7.2 Manufacturer´s qualification for firms producing welded joints between stainless steels and reinforcing steels

For welding stainless steels on reinforcing steels DIN EN ISO 17660:2006-12 applies with amendment 2007-08 in connection with DVS-guideline DVS 1708:2009 and the regulations of this national technical approval, especially section 4.7.1, paragraph (1) and (2).

4.7.3 Prerequisite for welding stainless steels

4.7.3.1 Plant equipment

The plant shall be provided with equipment and devices necessary for welding work, see DIN EN ISO 3834-3:2006-3, section 9.

4.7.3.2 Applied welding processes

For applying welding processes according to the sections 4.6.3, 4.6.5, 4.6.6 and 4.6.8 the expert reports required there shall be available. For arc welding according to section 4.6.2 procedure tests shall exist, if this is necessary according to section 4.6.2. For welding processes according to the sections 4.6.3 to 4.6.8 welding procedure tests are always required.

4.7.3.3 Welding supervisors

The required level of technical knowledge regarding the welding supervisor ensues according to Table 14 of DIN 18800-7:2008-11 in dependence on the class of the required constructor´s qualification. Accordingly, the welding supervisor shall have additionally proven in a technical discussion according to Element 1310 of DIN 18800-7:2009-11 in the face of the approved body

- thorough knowledge for the respective field of application and the steel grades according to 4.7.1.(2) in the relative strength class for the classes B and C
- thorough and comprehensive knowledge for the classes D and E

concerning welding and working up of components and constructions, including black-white joints.

4.7.3.4 Welder

For performing welding work, appropriately trained and approved welders according to DIN EN 287-1:2006-06 as well as trained and approved operators and set-up men according to DIN EN 1418:1998-01 shall be deployed. Welders carrying out fillet welding shall have welded a fillet weld test specimen. The welding manufacturer is obliged to necessarily make sure of work samples that the welder meets the quality requirements put on the component.

For the extension of validity of the welder´s qualification test according to DIN EN 287-1:2006-06 and DIN EN 1418:1998-01 the same rules apply as for the welders that are deployed in terms of DIN 18800-7:2008-11.

4.8 Verification of compliance and marking of the components

For the components prefabricated from the products and fasteners according to this national technical approval the verification of compliance applies analogously according to the *Bauregelliste A* (Building Rules List A) Part 1, ser. no. 4.10.2 and 4.10.5. Based on this verification of compliance - declaration of compliance of the manufacturer on the basis of a factory production control - the prefabricated components or the delivery notes shall be provided with the conformity mark Ü (Ü-mark). The name of the manufacturer and the number of this national technical approval shall be declared in the conformity mark.

5 Provisions for acceptance, service and maintenance

5.1 Acceptance

For the acceptances screws and welds shall be accessible. For welded joints that are no more accessible during final acceptance, an interim acceptance shall be provided. Before acceptance, welds shall get no or only a transparent coating.

5.2 Service and maintenance

To guarantee the structural safety of the components, the steel surface of such components classified as accessible shall be controlled and necessarily cleaned metallically bright at suitable intervals based on their individual utilization during the useful life of the building. If optical requirements exist, shorter distances of time may ensue.

If a regular control and cleaning was envisaged for the selection of material with regard to corrosion, the designer shall inform the user about this in written form. The performed controls and cleanings shall be documented.

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Table 1: Classification of steel grades regarding strength classes and corrosion resistance classes

Annex 1a
to *allgemeinen bauaufsichtlichen Zulassung*
Z-30.3-6
of 2 May 2011

Table 1

Steel designation[1)]			Micro-structure[2)]	Strength classes[3)] and product forms[4)]					Corrosion resistance class[5) 6)]
No.	Name	Number		S 235	S 275	S 355	S 460	S 690	
1	X2CrNi12	1.4003	F	B, Ba, H, P	D, H, S, W	D, S	D, S	---	I / low
2	X6Cr17	1.4016	F	D, S, W	---	---	---	---	
3	X5CrNi18-10	1.4301	A	B, Ba, D, H, P, S, W	B, Ba, D, H, P, S	B, Ba, D, H, S	Ba, D, H, S	S	
4	X2CrNi18-9	1.4307	A	B, Ba, D, H, P, S, W	B, Ba, D, H, P, S	Ba, D, H, S	Ba, D, S	S	
5	X3CrNiCu18-9-4	1.4567	A	D, S, W	D, S	D, S	D, S	---	II / moderate
6	X6CrNiTi18-10	1.4541	A	B, Ba, D, H, P, S, W	B, Ba, D, H, P, S	Ba, D, H, S	Ba, D, H, S	---	
7	X2CrNiN18-7	1.4318	A	---	---	B, Ba, D, H, P, S	B, Ba, H	---	
8	X5CrNiMo17-12-2	1.4401	A	B, Ba, D, H, P, S, W	B, Ba, D, H, P, S	Ba, D, H, S	Ba, D, S	S	
9	X2CrNiMo17-12-2	1.4404	A	B, Ba, D, H, P, S, W	B, Ba, D, H, P, S	Ba, D, H, S	Ba, D, H, S	D, S	
10	X3CrNiCuMo17-11-3-2	1.4578	A	D, S, W	D, S	D, S	D, S	---	III / medium
11	X6CrNiMoTi17-12-2	1.4571	A	B, Ba, D, H, P, S, W	B, Ba, D, H, P, S	Ba, D, H, S	Ba, D, H, S	D, S	
12	X2CrNiMoN17-13-5	1.4439	A	---	B, Ba, D, H, S, W	---	---	---	
13	X2CrNiN23-4	1.4362	FA	---	---	---	B, Ba, D, S, W	D, S	
14	X2CrNiMoN22-5-3	1.4462	FA	---	---	---	B, Ba, D, P, S, W	D, S	
15	X1NiCrMoCu25-20-5	1.4539	A	B, Ba, D, H, P, S, W	B, Ba, D, P, S	D, P, S	D, S	D, S	
16	X2CrNiMnMoNbN25-18-5-4	1.4565	A	---		---	B, Ba, D, S	---	IV / high
17	X1NiCrMoCuN25-20-7	1.4529	A	---	B, D, S, W	B, D, H, P, S	D,P, S	D, S	
18	X1CrNiMoCuN20-18-7	1.4547	A	---	B, Ba	B, Ba	---	---	

1) according to DIN EN 10088-1:2005-09

2) A = Austenite; F = Ferrite; FA = Ferrite – Austenite (Duplex)

3) The strength classes higher than the lowest are achieved by cold-working.

4) B = Plate; Ba = Strip and plates made of strips; D = Wire, drawn; H = Hollow sections; P = Sections; S = Rods; W = Wire, rolled

5) applies to metallic bright surfaces only. When bimetallic corrosion is possible the less noble metal may be jeopardised.

6) required corrosion resistance class see Annex 1.1, Table 1a

Exposure	Exposure class		Criteria und examples	Corrosion resistance class I	II	III	IV
humidity, yearly average value U of humidity	SF0	dry	U < 60 %	X			
	SF1	seldom moist	60 % ≤ U < 80 %	X			
	SF2	often moist	80 % ≤ U < 95 %	X			
	SF3	permanent moist	95 % < U		X		
chloride content of surrounding area, distance M from the sea, distance S from busy roads with road salt application	SC0	low	rural, urban, M > 10 km, S > 0.1 km	X			
	SC1	medium	industrial area, 10 km ≥ M > 1 km, 0.1 km ≥ S > 0.01 km		X		
	SC2	high	M ≤ 1 km S ≤ 0.01 km			X[1]	
	SC3	very high	indoor swimming pool, road tunnel				X[2]
exposure to redox affecting chemicals (e.g. SO_2, HOCl, Cl_2, H_2O_2)	SR0	low	rural, urban	X			
	SR1	medium	industrial area			X[1]	
	SR2	high	indoor swimming pool, road tunnel				X[2]
pH-value on the surface	SH0	alkaline (e.g. with contact to concrete)	9 < pH	X			
	SH1	neutral	5 < pH ≤ 9	X			
	SH2	low acidic (e.g. with contact to wood)	3 < pH ≤ 5		X		
	SH3	acidic (exposure to acids)	pH ≤ 3			X	
location of structural parts	SL0	indoors	indoors, heated and not heated	X			
	SL1	outdoors, exposed to rain	exposed structures		X[3]		
	SL2	outdoors, accessible but protected from weather	roofed structures		X[3]		
	SL3	outdoors, non-accessible[4], ambient air has access	accumulation of pollutants on surface by air pollution, cleaning not possible			X	

Only the exposure leading to the highest Corrosion Resistance Class (CRC) has to be taken into account. No higher requirements result from the coincidence of exposure conditions.

1) If **accessible** structures are cleaned regularly or exposed to rain corrosion will be much lower and the CRC may be reduced by one class. Otherwise the CRC has to be increased by one class if corrosion relevant substances can deposit and remain on the surfaces of structural parts.

2) If **accessible** structures are cleaned regularly corrosion will be much lower and the CRC may be reduced by one class.

3) If the life cycle is limited to 20 years and pitting corrosion up to 100 µm is tolerated CRC I may be chosen (no visual demands).

4) Structures are classified as **non-accessible** if an inspection of their condition is extremely difficult and a necessary rehabilitation is very expensive.

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Table 2
Steel grades for fasteners classified to steel groups according to DIN EN ISO 3506-1 and -2 as well as marking according to section 2.2.2 and maximum nominal diameter

Table 2

Steel designation				Corrosion resistance class[1]	Marking of bolts with head on the basis of DIN EN ISO 3506-1 Strength class			Marking of threaded bars, threaded dowels, nuts and washers on the basis of DIN EN ISO 3506-1 + -2 Strength class		
No.	Name	Number	Group		50	70	80	50	70	80
3	X5CrNi18-10	1.4301	A2	II / moderate	≤ M 39	≤ M 24	≤ M 20	≤ M 64	≤ M 45	≤ M 24
4	X2CrNi18-9	1.4307	A2L		≤ M 39	≤ M 24	≤ M 20	≤ M 64	≤ M 45	≤ M 24
5	X3CrNiCu18-9-4	1.4567	A2L		≤ M 24	≤ M 16	≤ M 12	≤ M 24	≤ M 16	≤ M 12
6	X6CrNiTi18-10	1.4541	A3		≤ M 39	≤ M 20	≤ M 16	≤ M 64	≤ M 30	≤ M 24
8	X5CrNiMo17-12-2	1.4401	A4	III / medium	≤ M 39	≤ M 24	≤ M 20	≤ M 64	≤ M 45	≤ M 24
9	X2CrNiMo17-12-2	1.4404	A4L		≤ M 39	≤ M 24	≤ M 20	≤ M 64	≤ M 45	≤ M 24
10	X3CrNiCuMo17-11-3-2	1.4578	A4L		≤ M 24	≤ M 16	≤ M 12	≤ M 24	≤ M 16	≤ M 12
11	X6CrNiMoTi17-12-2	1.4571	A5		≤ M 39	≤ M 24	≤ M 20	≤ M 64	≤ M 45	≤ M 24
12	X2CrNiMoN17-13-5	1.4439	[2]		≤ M 20	---	---	≤ M 64	---	---
13	X2CrNiN23-4	1.4362	[2]		---	≤ M 24	≤ M 20	---	≤ M 64	≤ M 20
14	X2CrNiMoN22-5-3	1.4462	[2]	IV / high	---	≤ M 24	≤ M 20	---	≤ M 64	≤ M 20
15	X1NiCrMoCu25-20-5	1.4539	[2] [3]		≤ M 39	≤ M 24	≤ M 20	≤ M 64	≤ M 45	≤ M 20
16	X2CrNiMnMoNbN25-18-5-4	1.4565	[2] [3]		---	≤ M 24	≤ M 20	---	≤ M 64	≤ M 30
17	X1NiCrMoCuN25-20-7	1.4529	[2] [3]		≤ M 30	≤ M 24	≤ M 20	≤ M 64	≤ M 45	≤ M 45

1) according to Annex 1, Table 1

2) Because there are no regulations so far this steel grades shall be marked with the steel number.

3) For fasteners in swimming pool atmospheres Annex 7, Table 10 applies.

Table 3

Strength class	Steel grades		$R_{p0,2}$	R_m	A_5 [1)]	
					%	
	No.acc. Table 1	Steel number.	N/mm²	N/mm²	Strip, plate flat producs	Rods, wire, pipes, sections, hollow sections
S 275	1	1.4003	275	550	-	25
	2	1.4016			-	25
	3	1.4301			40	25
	4	1.4307			40	25
	5	1.4567			-	25
	6	1.4541			40	25
	8	1.4401			40	25
	9	1.4404			40	25
	10	1.4578			-	25
	11	1.4571			40	25
	15	1.4539			40	25
S 355	1	1.4003	350	600	-	20
	3	1.4301			30	20
	4	1.4307			30	20
	5	1.4567			-	20
	6	1.4541			30	20
	8	1.4401			30	20
	9	1.4404			30	20
	10	1.4578			-	20
	11	1.4571			30	20
	15	1.4539			-	20
	17	1.4529			30	30
	18	1.4547			30	-
S 460	1	1.4003	460	600	-	10
	3	1.4301		650	20	12
	4	1.4307		650	20	12
	5	1.4567		650	-	12
	6	1.4541		650	20	12
	7	1.4318		650	20	12
	8	1.4401		650	20	12
	9	1.4404		650	20	12
	10	1.4578		650	-	12
	11	1.4571		650	20	12
	15	1.4539		650	-	12
	17	1.4529		650	-	22
S 690	9	1.4404	690	800	-	10
	11	1.4571		800	-	10
	13	1.4362		800	-	10
	14	1.4462		800	-	10
	15	1.4539		800	-	10
	16	1.4565		800	-	10
	17	1.4529		850	-	15

1) If no value is given the product is not available in this strength class or is not available in cold-worked state (properties according to DIN EN 10088-2)

Table 4

Parent material	Rod electrode acc. to DIN EN 1600	Wire electrodes, wire and rods acc. to DIN EN ISO 14343	Filler wire electrodes acc. to DIN EN ISO 17633
1.4003	19 9 L 18 8 Mn	19 9 L 18 8 Mn	19 9 L 18 8 Mn
1.4301	19 9 19 9 L 19 9 Nb	19 9 L 19 9 Nb	19 9 L 19 9 Nb
1.4307	19 9 L	19 9 L	19 9 L
1.4541	19 9 L 19 9 Nb	19 9 L 19 9 Nb	19 9 L 19 9 Nb
1.4318	19 9 L 19 9 Nb	19 9 L 19 9 Nb	19 9 L 19 9 Nb
1.4401	19 12 2 19 12 3 L 19 12 3 Nb	19 12 3 L 19 12 3 Nb	19 12 3 L 19 12 3 Nb
1.4404	19 12 3 L	19 12 3 L	19 12 3 L
1.4571	19 12 3 L 19 12 3 Nb	19 12 3 L 19 12 3 Nb	19 12 3 L 19 12 3 Nb
1.4539	NiCr22Mo9Nb1)	20 25 5 Cu N L NiCr22Mo9Nb2)	-
1.4439	18 16 5 N L	18 16 5 N L	18 16 5 N L
1.4362, 1.4462	22 9 3 N L	22 9 3 N L	22 9 3 N L
1.4529	NiCr23Mo16 1) NiCr22Mo9Nb1)	NiCr23Mo16Cu2 2) NiCr22Mo9Nb2)	-
1.4547	NiCr22Mo9Nb1)	NiCr22Mo9Nb2)	-
1.4565	NiCr19Mo15 1)	NiCr20Mo15 2)	-

1) according to DIN EN ISO 14172:2004-05
2) according to DIN EN ISO 18274:2004-05

Table 5

1	2	3	4
Rod electrodes acc. to DIN EN 1600	**Wire electrodes, wire and rods acc. to DIN EN ISO 14343**	**Filled wire electrodes acc. to DIN EN ISO 17633**	**Yield strength $f_{y,k}$ 1)** **N/mm²**
23 12 L 23 12 2 L 20 10 3 18 8 Mn	23 12 L 23 12 2 L 20 10 3 18 8 Mn	23 12 L 23 12 2 L 20 10 3 18 8 Mn	320 350 400 350
NiCr20Mn3Nb[2)] NiCr16Fe12NbMo[2)]	NiCr20Mn3Nb[3)] NiCr20Mo15[3)]	-	355 355

1) Shall be used as characteristic value for calculation of load bearing capacity of welded joins according to section 3.3.5.7
2) according to DIN EN ISO 14172:2004-05
3) according to DIN EN ISO 18274:2004-05

Table 6

1	2	3	4
Rod electrodes acc. to DIN EN 1600	**Wire electrodes, wire and rods acc. to DIN EN ISO 14343**	**Filled wire electrodes acc. to DIN EN ISO 17633**	**Yield strength $f_{y,k}$ 1)** **N/mm²**
18 8 Mn 20 10 3 23 12 L 23 12 2 L	18 8 Mn 20 10 3 23 12 L 23 12 2 L	18 8 Mn 20 10 3 23 12 L 23 12 2 L	350 400 320 350
NiCr20Mn3Nb[2)] NiCr16Fe12NbMo[2)]	NiCr20Mn3Nb[3)] NiCr20Mo15[3)]	-	355 355
NiCr23Mo16[2)] NiCr22Mo9Nb[2)]	NiCr23Mo16Cu2[3)] NiCr22Mo9Nb[3)]	-	355 355
NiCr19Mo15[2)]	NiCr20Mo15[3)]	-	355

4) Shall be used as characteristic value for calculation of load bearing capacity of welded joins according to section 3.3.5.7
5) according to DIN EN ISO 14172:2004-05
6) according to DIN EN ISO 18274:2004-05

Table 7

1	2	3	4
Rod electrodes acc. to DIN EN 1600	**Wire electrodes, wire and rods acc. to DIN EN ISO 14343**	**Filled wire electrodes acc. to DIN EN ISO 17633**	**Yield strength $f_{y,k}$ 1)** **N/mm²**
22 9 3 N L	22 9 3 N L	22 9 3 N L	450
NiCr20Mn3Nb[2)] NiCr16Fe12NbMo[2)]	NiCr20Mn3Nb[3)] NiCr20Mo15[3)]	-	355 355

1) Shall be used as characteristic value for calculation of load bearing capacity of welded joins according to section 3.3.5.7
2) according to DIN EN ISO 14172:2004-05
3) according to DIN EN ISO 18274:2004-05

Table 8

Strength class	Plate, strip and hollow sections			Rods and wire, extruded and cold-formed sections		
	No. acc. to Table 1	Steel number	max t[1)] mm	No. acc. to Table 1	Steel number	max d[1)] mm
S 275	3	1.4301	12.5	1	1.4003	80
	4	1.4307	6	3	1.4301	80
	6	1.4541	6	4	1.4307	80
	8	1.4401	6	5	1.4567	30
	9	1.4404	12.5	6	1.4541	60
	11	1.4571	6	8	1.4401	80
	15	1.4539	6	9	1.4404	80
				10	1.4578	30
				11	1.4571	80
				15	1.4539	80
S 355	3	1.4301	8	1	1.4003	80
	4	1.4307	6	3	1.4301	60
	6	1.4541	6	4	1.4307	60
	8	1.4401	6	5	1.4567	30
	9	1.4404	8	6	1.4541	50
	11	1.4571	6	8	1.4401	60
	17	1.4529	6	9	1.4404	60
	18	1.4547	6	10	1.4578	30
				11	1.4571	40
				15	1.4539	80
				17	1.4529	80
S 460	3	1.4301	6	1	1.4003	60
	4	1.4307	4	3	1.4301	50
	6	1.4541	6	4	1.4307	50
	7	1.4318	6	5	1.4567	42
	8	1.4401	4	6	1.4541	30
	9	1.4404	6	8	1.4401	50
	11	1.4571	6	9	1.4404	50
				10	1.4578	42
				11	1.4571	22
				15	1.4539	50
				17	1.4529	50
S 690				3	1.4301	22
				4	1.4307	22
				6	1.4541	22
				8	1.4401	22
				9	1.4404	22
				11	1.4571	22
				13	1.4362	60
				14	1.4462	60
				15	1.4539	50
				17	1.4529	50

1) Bigger values are allowed if verified during initial type testing by testing of the mechanical and technological parameters and reported in the initial type testing report and in the conformity mark.

Table 9

Plate, strip and hollow sections			Rods and wire, extruded and cold-formed sections		
No. acc. to Table 1	Steel number	max t[1)] mm	No. acc. to Table 1	Steel number	max t[1)] mm
1	1.4003	12	1	1.4003	25
3 8	1.4301 1.4401	6[2)]	3 8	1.4301 1.4401	25[2)]
4 6 7 9 11	1.4307 1.4541 1.4318 1.4404 1.4571	30	4 6 7 9 11	1.4307 1.4541 1.4318 1.4404 1.4571	45
12 15 16 17 18	1.4439 1.4539 1.4565 1.4529 1.4547	12	12 15 16 17	1.4439 1.4539 1.4565 1.4529	25
13 14	1.4362 1.4462	30	13 14	1.4362 1.4462	45

1) For bigger thicknesses a welding procedure qualification for each thickness and kind of welded joint is required.

2) For bigger thicknesses the resistance against intergranular corrosion shall be proved according to DIN EN ISO 3651.

Table 10

Structural parts in swimming pool atmospheres	**Steel grades**
with regular cleaning of the structural parts	Choice of corrosion resistance class according to Table 1a
without regular cleaning [1)] of the structural parts in the area of water according to *Trinkwasserverordnung*[2)] (regulation for drinking water) Cl ≤ 250 mg/l	1.4539 1.4565 1.4529 1.4547
without regular cleaning [1)] of the structural parts in the area of chloride rich water[2)] (e.g. brine water), Cl > 250 mg/l	1.4565 1.4529 1.4547

1) see *Merkblatt 831 "Edelstahl Rostfrei in Schwimmbädern (MB 831)"* (Information sheet 831 “Stainless steels in swimming pools” (MB 831)) 2nd edition 2000 of *Informationsstelle Edelstahl Rostfrei* (information centre for stainless steels)

2) Splash water and aerosols shall be considered which may reach areas not accessible and not cleaned regularly e.g. via ventilation and leading there to high concentrations

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Table 11:
Characteristic values for structural parts
welded joints included

Table 11

1	2	3		4		5	6	7	8	9
Strength class	Steel number	Yield strength				Tension resistance	E-Modulus, modulus of shear (G)		Coefficient of thermal expansion	Density
		structural parts[1]		welded joints[2]			for structural calculations			
		cold rolled strip[3]	other	cold rolled strip[3]	other		general[4] except by constraint stresses and proof of stability acc. to section 3.3.2.3	constraint stresses		
		$f_{y,k}$		$f_{y,k}$		$f_{u,k}$	E G	E G		
		N/mm²		N/mm²		N/mm²	N/mm²	N/mm²	10^{-6} x K^{-1}	kg/dm³
S 235	1.4567	--	175	--	--	450				7.9
	1.4578									8.0
	1.4301									7.9
	1.4307	220	190	220	190					
	1.4541									
	1.4401					500	170 000	200 000	16	
	1.4404	240	200	240	200					
	1.4571						65 400	76 900		8.0
	1.4539	240	220	240	220					
	1.4003	240	240	240	240	450			10	7.7
	1.4016	--	240	--	--	400				
S 275	1.4301									
	1.4307	275		275	275					
	1.4541									7.9
	1.4567	--		--	--		170 000	200 000	16	
	1.4578									
	1.4401					550				
	1.4404	275	275	275	275		65 400	76 900		
	1.4571									8.0
	1.4539									
	1.4003	--		--					10	7.7
	1.4439	290		290	275				16	8.0
	1.4529	300	300	300	300					8.1
	1.4547	275	--	275	--	600			17	8.0
S 355	1.4003	--	355	--	320				10	7.7
	1.4318	350	330	350	300					
	1.4301									
	1.4307	355		355	355					
	1.4541									7.9
	1.4567	--		--	--		170 000	200 000	16	
	1.4578		355			600				
	1.4401									
	1.4404	355		355	355		65 400	76 900		8.0
	1.4571									
	1.4539	--		--	320					
	1.4529	355		355	355					8.1
	1.4547		--		--				17	8.0

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Table 11:
Characteristic values for structural parts
welded joints included

Annex 8.2a
to allgemeinen
bauaufsichtlichen Zulassung
Z-30.3-6
of 2 May 2011

Table 11

1	2	3		4		5	6	7	8	9
Strength class	Steel number	Yield strength				Tension resistance	E-Modulus, modulus of shear (G)		Coefficient of thermal expansion	Density
		structural parts[1]		welded joints[2]			for structural calculations			
		cold rolled strip[3]	other	cold rolled strip[3]	other		general[4] except by constraint stresses and proof of stability acc. to section 3.3.2.3	constraint stresses		
		$f_{y,k}$		$f_{y,k}$		$f_{u,k}$	E G	E G		
		N/mm²		N/mm²		N/mm²	N/mm²	N/mm²	10^{-6} x K^{-1}	kg/dm³
S 460	1.4565	460	420	350	350				16	8.0
	1.4003	--		--	320				10	7.7
	1.4301		460		355					
	1.4307	460		355						7.9
	1.4318		--		--					
	1.4541				355					
	1.4567	--		--	--		170 000	200 000		
	1.4578								16	
	1.4401	460	460	355	355	600				
	1.4404						65 400	76 900		8.0
	1.4539	--		--	320					
	1.4571	460		355	355					
	1.4529	--		--	420					8.1
	1.4362	450	400	400	400	600	200 000		13	7.8
	1.4462	480	460	450	450		76 900			
S 690	1.4301	--		--	355					7.9
	1.4307									
	1.4539				320					8.0
	1.4529				420	800	170 000	200 000	16	8.1
	1.4401		690							
	1.4404				355					8.0
	1.4571						65 400	76 900		
	1.4362	--		--	400				13	7.8
	1.4462				450					

1) For proofs of stability section 3.3.1.1(2) shall be considered.
2) At the suitability test on the welding consumables according to DIN EN 13479 shall be verified additional and recorded in the suitability test report that the yield strength is riched . The maximum values for calculation of mixed joints are listed in Table 5 to 7. This applies only to the welding processes 111, 121, 131, 135, 136 und 141.
3) According to DIN EN 10088-4
4) For proofs of stability according to sections 3.3.7 to 3.3.9 section 3.3.2.3 shall be considered

Table 12

	1	2	3
	Strength class	Yield strength $f_{y,b,k}$ N/mm²	Tensile strength $f_{u,b,k}$ N/mm²
1	50	210	500
2	70	450	700
3	80	600	800

Table 13

<table>
<tr><td rowspan="2"></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Welds acc. to DIN 18800-1, Table 19</td><td>Weld quality</td><td>Kind of loading</td><td>Austenitic steel grades and steel grades 1.4362 and 1.4462</td><td>Steel 1.4003</td></tr>
<tr><td>1</td><td rowspan="3">Line 1-4</td><td>all weld qualities</td><td>compression</td><td rowspan="2">1.0[1)]</td><td rowspan="2">1.0[1)]</td></tr>
<tr><td>2</td><td>weld quality proved</td><td rowspan="2">tension, shear</td></tr>
<tr><td>3</td><td>weld quality not proved</td><td rowspan="2">0.95</td><td rowspan="2">0.80</td></tr>
<tr><td>4</td><td>Line 5-15</td><td>all weld qualities</td><td>compression, tension, shear</td></tr>
</table>

1) Generally it is not necessary to calculate this welds the resistance of the parent material of the structural parts is relevant for structural design.

Table 14

Buckling stress curves	a	b	c	d
$f_{y,k}$ in N/mm²				
175	0.69	0.93	1.18	1.67
190	0.67	0.90	1.14	1.60
200	0.65	0.88	1.12	1.56
220	0.62	0.84	1.08	1.50
240	0.60	0.82	1.04	1.45
275	0.57	0.78	1.00	1.38
300	0.55	0.75	0.97	1.34
330	0.53	0.73	0.94	1.30
355	0.52	0.71	0.92	1.27
420	0.49	0.67	0.88	1.23
460	0.47	0.66	0.86	1.22

1 [1]	2 ...4 [2]	5	
3		$\kappa = 1$	for $\bar{\lambda}_P \le \bar{\lambda}_{P,grenz}$
		$\kappa = 0.74 \cdot c \cdot (\frac{1}{\bar{\lambda}_P} - \frac{0.22}{\bar{\lambda}_P^2})$	for $\bar{\lambda}_P > \bar{\lambda}_{P,grenz}$
		with $c = 1.25 - 0.25 \cdot \psi \le 1.25$	and
		$\bar{\lambda}_{P,grenz} = \eta \cdot (c + \sqrt{c^2 - 0.88 \cdot c}) \cdot 0.5$	
4		$\kappa = 1$	for $\bar{\lambda}_P \le \bar{\lambda}_{P,grenz}$
		$\kappa = \frac{1}{1.1 \cdot \bar{\lambda}_P^2 + 0.87}$	for $\bar{\lambda}_P > \bar{\lambda}_{P,grenz}$
		with $\bar{\lambda}_{P,grenz} = 0.7 \cdot \eta$	
5		$\kappa = 1$	for $\bar{\lambda}_P \le \bar{\lambda}_{P,grenz}$
		$\kappa = \frac{0.68}{\bar{\lambda}_P} - \frac{0.11}{\bar{\lambda}_P^2}$	for $\bar{\lambda}_{P,grenz} < \bar{\lambda}_P < 0.6875$
		$\kappa = \frac{0.52}{\bar{\lambda}_P}$	for $\bar{\lambda}_P \ge 0.6875$
		with $\bar{\lambda}_{P,grenz} = 0.7 \cdot \eta$	
6		$\kappa_\tau = 1$	for $\bar{\lambda}_P \le \bar{\lambda}_{P,grenz}$
		$\kappa_\tau = \frac{0.82}{\bar{\lambda}_P} - \frac{0.16}{\bar{\lambda}_P^2}$	for $\bar{\lambda}_{P,grenz} < \bar{\lambda}_P < 0.8$
		$\kappa_\tau = \frac{0.62}{\bar{\lambda}_P}$	for $\bar{\lambda}_P \ge 0.8$
		with $\bar{\lambda}_{P,grenz} = 0.84 \cdot \eta$	
7		$\kappa_\tau = 1$	for $\bar{\lambda}_P \le \bar{\lambda}_{P,grenz}$
		$\kappa_\tau = \frac{0.82}{\bar{\lambda}_P} - \frac{0.16}{\bar{\lambda}_P^2}$	for $\bar{\lambda}_{P,grenz} < \bar{\lambda}_P < 0.8$
		$\kappa_\tau = \frac{0.62}{\bar{\lambda}_P}$	for $0{,}8 \le \bar{\lambda}_P \le 1.79$
		$\kappa_\tau = \frac{1.11}{\bar{\lambda}_P^2}$	for $\bar{\lambda}_P > 1.79$
		with $\bar{\lambda}_{P,grenz} = 0.84 \cdot \eta$	

$\eta = \sqrt{\frac{E_{sek,y}}{E}}$ applies with $E_{sek,y}$ = secant modulus according to section 3.3.2.3.2(1)

E = elasticity modulus according to Table 11, line 6

[1] Line 1 and 2 of Table 1 of DIN 18800-3:2008-11 do not apply because only unstiffened plates are considered.
[2] The text of Table 1 of DIN 18800-3:2008-11 applies unchanged for column 2 to 4.

Remark: f_{yk} shall be taken from Table 11, column 3 under attention of section 3.3.1.1(2), σ_{pi} and τ_{Pi} shall be calculated with σ_e according to section 3.3.8.2.

Table 16

Line	Range of validity
1	d ≤ 150mm h ≤ 340mm b ≤ 340mm
2	0.5 ≤ h/b ≤ 2.0
3	1.5mm ≤ t ≤ 15mm
4	d/t ≤ 35 b/t ≤ 35

Table 17

	Range of validity	
Line	with	without
	stiffening plate	
1	b ≤ 340mm	b ≤ 240mm
	h ≤ 340mm	h ≤ 240mm
2	0.33 ≤ h/b ≤ 3.5	
3	2.5mm ≤ t ≤ 15mm	
4	b/t ≤ 26 ; h/t ≤ 26	

In the 22 Tables of this Annex, the characteristic values of the real buckling stresses $\sigma_{S,R,k}$ according to DIN 18800-4 Element 203 are indicated in dependence on the shell slenderness $\bar{\lambda}_s$ that shall be determined according to DIN 18800-4 Element 203 using the values E und $f_{y,k}$ according to section 3.3.9.2.

1. For normal cases of shell buckling susceptible to imperfection, the tables for which κ_1 is indicated in the upper left corner in brackets apply according to the equations 7 in Element 204. For shell slendernesses $\bar{\lambda}_s \geq 2.00$, equation 7c in DIN 18800-4 Element 204 applies using the values E and $f_{y,k}$ according to section 3.3.9.2 of this approval.

   If the value $\sigma_{S,R,k}/f_{y.k}$ determined with the tabular values is smaller than the value $\Psi\ \kappa_2$, determined for the same value Ψ according to section 3.3.9.4, the value $\Psi\ \kappa_2\ f_{y,k}$ may be set as characteristic value of the real buckling stress.

2. For cases of shell buckling very susceptible to imperfection according to the equations 8 in Element 204 – unless it does not concern the cylindrical shell with compressive load in axial direction treated in section 3.3.9.4 – those tables apply for which κ_2 is indicated in the upper left corner in brackets. .

   a) For shell slendernesses $1.35 \leq \bar{\lambda}_s < 1.58$ equation 8b applies, in which $\bar{\lambda}_s$ shall be substituted by $0.4\sqrt{\bar{\lambda}_s}$. When determining the characteristic values of the real buckling stresses $\sigma_{S,R,k}$ according to Element 203 of DIN 18800-4, the value $f_{y,k}$ shall be substituted by $0.4f_{y,k}$ as well.

   b) For shell slendernesses $1.58 \leq \bar{\lambda}_s < 2.37$ equation 8c applies, in which $\bar{\lambda}_s$ shall be substituted by $0.4\sqrt{\bar{\lambda}_s}$. When determining the characteristic values of the real buckling stresses $\sigma_{S,R,k}$ according to Element 203 of DIN 18800-4, the value $f_{y,k}$ shall be substituted by $0.4f_{y,k}$ as well. In this case, a higher characteristic value of the real buckling stress ensues, if instead of the yield strength specified for the steel according to Table 11 and section 3.3.1.1(2), a reduced value of $f_{y,k}^* = 2.5\sigma_{Si}$ is set, with the ideal buckling stress σ_{Si}. $f_{y,k}^* \geq 190 N/mm^2$ shall be kept.

   c) For shell slendernesses $2.37 \leq \bar{\lambda}_s$ equation 8d according to Element 204 of DIN 18800-4 applies.

   In the cases 2a) to 2c) the values E and $f_{y,k}$ according to section 3.3.9.2.

From the values given in the Tables or the characteristic values of the real buckling stress determined with the previously mentioned formulae beyond the range of values of the Tables, the design values $\sigma_{S,R,d}$ with the partial safety factors of the resistances shall be determined according to the equations 12 and 13 in Element 206 of DIN 18800-4.

When determining the real buckling stress under shear stress, $f_{y,k}/\sqrt{3}$ shall be applied instead of $f_{y,k}$, and the Tables as well as the above regulations apply for normal cases of shell buckling (κ_1) susceptible to imperfection.

$\bar{\lambda}_s$ (κ_1)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	190	190	190	190	190	190	190	190	190	190
0.1	190	190	190	190	190	190	190	190	190	190
0.2	190	190	190	190	190	188	185	183	181	179
0.3	177	175	172	170	168	166	164	162	159	157
0.4	155	154	152	150	148	146	145	143	141	140
0.5	138	137	135	134	132	131	129	128	126	125
0.6	124	122	121	120	119	117	116	115	114	113
0.7	111	110	109	108	107	106	105	104	103	102
0.8	101	100	99	98	97	96	95	94	93	92
0.9	91	90	89	88	88	87	86	85	84	83
1.0	93	82	81	80	79	79	78	77	76	76
1.1	75	74	73	73	72	71	70	70	69	68
1.2	68	67	66	66	65	64	64	63	63	32
1.3	61	61	60	59	59	58	58	57	57	56
1.4	55	55	54	54	53	53	52	52	51	51
1.5	50	50	49	49	48	48	47	47	46	46
1.6	45	45	44	44	44	43	43	42	42	41
1.7	41	41	40	39	39	39	39	38	38	37
1.8	37	37	36	36	36	35	35	35	34	34
1.9	34	34	34	33	33	32	32	32	32	31

$\bar{\lambda}_s$ (κ_2)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.1	190	190	190	190	190	190	187	184	181	178
0.2	175	172	169	166	163	160	157	154	151	149
0.3	146	144	141	139	137	135	132	130	128	126
0.4	124	123	121	119	117	115	114	112	111	109
0.5	107	106	104	103	101	100	99	97	96	95
0.6	93	92	91	89	88	87	86	85	83	82
0.7	81	80	79	78	77	76	75	74	73	72
0.8	71	70	69	68	67	66	65	64	63	62
0.9	61	60	60	59	58	57	56	56	55	54
1.0	53	53	52	51	50	50	49	48	48	47
1.1	46	46	45	44	44	43	42	42	41	41
1.2	40	40	39	38	83	37	37	36	36	35
1.3	35	34	34	34	33	33	33	32	32	31

$\bar{\lambda}_s$ (κ_1)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	200	200	200	200	200	200	200	200	200	200
0.1	200	200	200	200	200	200	200	200	200	200
0.2	200	200	200	200	200	198	196	194	192	189
0.3	187	185	183	180	178	176	174	171	169	167
0.4	165	163	161	159	157	155	153	152	150	148
0.5	146	145	143	142	140	138	137	135	134	133
0.6	131	130	128	127	126	124	123	122	121	119
0.7	118	117	116	115	113	112	111	110	109	108
0.8	107	106	105	103	102	101	100	99	98	97
0.9	96	96	95	94	93	92	91	90	89	88
1.0	87	86	86	85	84	83	82	81	81	80
1.1	79	78	78	77	76	75	74	74	73	72
1.2	72	71	70	69	69	68	67	67	66	65
1.3	65	64	63	63	62	62	61	60	60	59
1.4	59	58	57	57	56	56	55	55	54	53
1.5	53	52	52	51	51	50	50	49	49	48
1.6	48	47	47	46	46	45	45	45	44	44
1.7	43	43	42	42	41	41	41	40	40	39
1.8	39	39	38	38	38	38	37	36	36	36
1.9	36	36	35	35	35	34	34	33	33	33

$\bar{\lambda}_s$ (κ_2)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.1	200	200	200	200	200	200	198	194	191	188
0.2	185	182	179	176	173	170	166	163	161	158
0.3	155	152	150	147	145	143	140	138	136	134
0.4	132	130	128	126	124	122	121	119	117	115
0.5	114	112	111	109	107	106	104	103	102	100
0.6	99	97	96	95	93	92	91	89	88	87
0.7	86	85	83	82	81	80	79	78	77	76
0.8	75	74	73	72	71	70	69	68	67	66
0.9	65	64	63	62	61	60	60	59	58	57
1.0	56	55	55	54	53	52	52	51	50	49
1.1	49	48	47	47	46	45	45	44	44	43
1.2	42	42	41	41	40	39	39	38	38	37
1.3	37	36	36	35	35	35	34	34	33	33

$\bar{\lambda}_s$ (κ_1)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	220	220	220	220	220	220	220	220	220	220
0.1	220	220	220	220	220	220	220	220	220	220
0.2	220	220	220	220	220	220	218	215	213	210
0.3	208	206	203	201	198	196	194	191	189	186
0.4	184	182	179	177	175	173	171	169	167	165
0.5	163	161	160	158	156	154	153	151	149	148
0.6	146	145	143	142	140	139	137	136	134	133
0.7	131	130	129	127	126	125	124	122	121	120
0.8	119	117	116	115	114	113	112	111	109	108
0.9	107	106	105	104	103	102	101	100	99	98
1.0	97	96	95	94	93	92	91	90	90	89
1.1	88	87	86	85	84	83	83	82	81	80
1.2	79	79	78	77	76	75	75	74	73	72
1.3	72	71	70	70	69	68	67	67	66	65
1.4	65	64	63	63	62	61	61	60	60	59
1.5	58	58	57	57	56	56	55	54	54	53
1.6	53	52	52	51	51	50	50	49	49	48
1.7	48	47	47	46	46	45	45	44	44	43
1.8	43	43	42	42	41	41	41	40	40	40
1.9	40	39	39	38	38	38	37	37	36	36

$\bar{\lambda}_s$ (κ_2)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.1	220	220	220	220	220	220	219	216	212	209
0.2	206	202	199	196	193	189	186	182	179	176
0.3	173	170	167	164	162	159	157	154	152	149
0.4	147	145	143	141	138	136	134	132	130	129
0.5	127	125	123	121	120	118	116	115	113	111
0.6	110	108	107	105	104	102	101	99	98	97
0.7	95	94	93	91	90	89	88	86	85	84
0.8	83	82	80	79	78	77	76	75	74	73
0.9	72	71	70	69	68	67	66	65	64	63
1.0	62	61	60	60	59	58	57	56	55	55
1.1	54	53	52	52	51	50	49	49	48	47
1.2	47	46	45	45	44	43	43	42	42	41
1.3	41	40	39	39	38	38	38	37	37	36

$\bar{\lambda}_s$ (κ_1)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	240	240	240	240	240	240	240	240	240	240
0.1	240	240	240	240	240	240	240	240	240	240
0.2	240	240	240	240	240	240	239	237	234	232
0.3	229	226	224	221	219	216	214	211	209	206
0.4	203	201	198	196	194	191	189	187	185	182
0.5	180	178	176	174	172	170	169	167	165	163
0.6	161	160	158	156	155	153	151	150	148	147
0.7	145	144	142	141	139	138	136	135	134	132
0.8	131	129	128	127	126	124	123	122	121	119
0.9	118	117	116	115	113	112	111	110	109	108
1.0	107	106	105	104	103	101	100	99	98	97
1.1	96	95	95	94	93	92	91	90	89	88
1.2	87	86	85	84	84	83	82	81	80	79
1.3	79	78	77	76	75	75	74	73	72	72
1.4	71	70	70	69	68	67	67	66	65	65
1.5	64	63	63	62	61	61	60	60	59	58
1.6	58	57	57	56	55	55	54	54	53	53
1.7	52	52	51	51	50	49	49	48	48	48
1.8	47	47	46	46	45	45	44	44	43	43
1.9	43	43	42	42	41	41	41	40	40	39

$\bar{\lambda}_s$ (κ_2)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.1	240	240	240	240	240	240	240	237	233	230
0.2	226	223	219	216	212	209	206	202	198	195
0.3	191	188	185	182	179	176	173	170	168	165
0.4	162	160	157	155	153	150	148	146	144	142
0.5	140	138	136	134	132	130	128	126	124	123
0.6	121	119	118	116	114	113	111	109	108	106
0.7	105	103	102	100	99	98	96	95	94	92
0.8	91	90	88	87	86	85	83	82	81	80
0.9	79	78	77	75	74	73	72	71	70	69
1.0	68	67	66	65	64	63	63	62	61	60
1.1	59	58	57	56	56	55	54	53	53	52
1.2	51	50	50	49	48	48	47	46	46	45
1.3	44	44	43	42	42	42	41	41	40	40

$\bar{\lambda}_s$ (κ_1)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	275	275	275	275	275	275	275	275	275	275
0.1	275	275	275	275	275	275	275	275	275	275
0.2	275	275	275	275	275	275	275	274	271	269
0.3	266	263	260	257	254	252	249	246	243	240
0.4	238	235	232	229	226	224	221	218	216	213
0.5	211	208	206	204	201	199	197	195	192	190
0.6	188	186	184	182	180	178	176	175	173	171
0.7	169	167	166	164	162	160	159	157	155	154
0.8	152	151	149	148	146	145	143	142	140	139
0.9	137	136	135	133	132	130	129	128	127	125
1.0	124	123	121	120	119	118	117	115	114	113
1.1	112	111	110	108	107	106	105	104	103	102
1.2	101	100	99	98	97	96	95	94	93	92
1.3	91	90	89	88	87	86	85	85	84	83
1.4	82	81	80	79	79	78	77	76	75	75
1.5	74	73	72	71	71	70	69	69	68	67
1.6	66	66	65	64	64	63	62	62	61	60
1.7	60	59	59	58	57	57	56	56	55	55
1.8	54	54	53	53	52	51	51	50	50	50
1.9	50	49	48	48	47	47	47	46	46	45

$\bar{\lambda}_s$ (κ_2)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.1	275	275	275	275	275	275	275	274	270	266
0.2	262	258	255	251	247	243	239	235	232	227
0.3	223	220	216	212	209	205	202	199	196	193
0.4	190	187	184	181	178	176	173	170	168	165
0.5	163	160	158	156	154	151	149	147	145	143
0.6	141	139	137	135	133	131	129	127	125	124
0.7	122	120	118	117	115	113	112	110	109	107
0.8	105	104	102	101	99	98	97	95	94	93
0.9	91	90	89	87	86	85	83	82	81	80
1.0	79	78	76	75	74	73	72	71	70	69
1.1	68	67	66	65	64	63	62	61	60	60
1.2	59	58	57	56	55	55	54	53	52	52
1.3	51	50	49	49	48	48	47	47	46	45

$\bar{\lambda}_s$ (κ_1)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	290	290	290	290	290	290	290	290	290	290
0.1	290	290	290	290	290	290	290	290	290	290
0.2	290	290	290	290	290	290	290	290	287	284
0.3	281	279	276	273	270	267	264	261	258	255
0.4	252	249	246	243	240	238	235	232	229	226
0.5	224	221	219	216	214	211	209	207	204	202
0.6	200	198	196	193	191	198	187	185	183	181
0.7	179	178	176	174	172	170	168	167	165	163
0.8	162	160	158	157	155	153	152	150	149	147
0.9	146	144	143	141	140	138	137	136	134	133
1.0	131	130	129	127	126	125	123	122	121	120
1.1	118	117	116	115	114	113	111	110	109	108
1.2	107	106	105	104	102	101	100	99	98	97
1.3	96	95	94	93	92	91	90	89	88	88
1.4	87	86	85	84	83	82	81	80	80	79
1.5	78	77	76	76	75	74	73	72	72	71
1.6	70	69	69	68	67	67	66	65	65	64
1.7	63	63	62	61	61	60	59	59	58	58
1.8	57	57	56	55	55	54	54	53	53	52
1.9	52	52	51	51	50	50	49	49	48	48

$\bar{\lambda}_s$ (κ_2)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.1	290	290	290	290	290	290	290	290	286	282
0.2	278	274	270	266	262	258	254	250	246	242
0.3	238	233	229	226	222	218	215	211	208	205
0.4	201	198	195	192	189	186	184	181	178	176
0.5	173	170	168	165	163	161	158	156	154	151
0.6	149	147	145	143	141	139	137	135	133	131
0.7	129	127	125	124	122	120	118	117	115	113
0.8	112	110	108	107	105	104	103	101	99	98
0.9	96	95	94	92	91	90	88	87	86	84
1.0	83	82	81	80	78	77	76	75	74	73
1.1	72	71	70	69	68	67	66	65	64	63
1.2	62	61	60	59	58	58	57	56	55	54
1.3	54	53	52	51	51	51	50	49	49	48

$\bar{\lambda}_s$ (κ_1)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	300	300	300	300	300	300	300	300	300	300
0.1	300	300	300	300	300	300	300	300	300	300
0.2	300	300	300	300	300	300	300	300	298	295
0.3	292	289	286	283	280	277	274	271	268	265
0.4	262	259	256	253	250	247	244	241	238	235
0.5	233	230	227	225	222	220	217	215	212	210
0.6	208	206	203	201	199	197	195	193	190	188
0.7	186	185	183	181	179	177	175	173	171	170
0.8	168	166	164	163	161	159	158	156	154	153
0.9	151	150	148	147	145	144	142	141	139	138
1.0	136	135	134	132	131	129	128	127	126	124
1.1	123	122	120	119	118	117	115	114	113	112
1.2	111	110	108	107	106	105	104	103	102	101
1.3	100	99	98	97	96	95	94	93	92	91
1.4	90	89	88	87	86	85	84	83	82	82
1.5	81	80	79	78	77	77	76	75	74	73
1.6	73	72	71	70	70	69	68	68	67	66
1.7	65	65	64	63	63	62	62	61	60	60
1.8	59	58	58	57	57	56	56	55	54	54
1.9	54	53	53	52	52	51	51	50	50	49

$\bar{\lambda}_s$ (κ_2)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.1	300	300	300	300	300	300	300	300	296	292
0.2	288	286	280	276	272	268	264	260	255	251
0.3	247	243	239	235	231	227	223	220	216	213
0.4	209	206	203	200	197	194	191	188	185	182
0.5	180	177	174	172	169	167	164	162	160	157
0.6	155	153	151	148	146	144	142	140	138	136
0.7	134	132	130	128	126	152	123	121	119	118
0.8	116	114	113	111	109	108	106	105	103	102
0.9	100	99	97	96	94	93	92	90	89	88
1.0	86	85	84	83	81	80	79	78	77	75
1.1	74	73	72	71	70	69	68	67	66	65
1.2	64	63	62	61	61	60	59	58	57	56
1.3	56	55	54	53	53	52	52	51	50	50

$\bar{\lambda}_s$ (κ_1)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	330	330	330	330	330	330	330	330	330	330
0.1	330	330	330	330	330	330	330	330	330	330
0.2	330	330	330	330	330	330	330	330	330	327
0.3	324	320	317	314	311	308	304	301	298	295
0.4	291	288	285	282	278	275	272	269	266	262
0.5	259	256	253	251	248	245	242	239	237	234
0.6	231	229	226	224	222	219	217	214	212	210
0.7	208	205	203	201	199	197	195	193	191	189
0.8	187	185	183	181	179	177	175	173	172	170
0.9	168	166	165	163	161	160	158	156	155	153
1.0	151	150	148	147	145	144	142	141	139	138
1.1	136	135	133	132	131	129	128	127	125	124
1.2	123	121	120	119	118	116	115	114	113	112
1.3	110	109	108	107	106	105	104	102	101	100
1.4	99	98	97	96	95	94	93	92	91	90
1.5	89	88	87	86	85	85	84	83	82	81
1.6	80	79	78	78	77	75	75	74	74	73
1.7	72	71	71	70	69	68	68	67	66	66
1.8	65	65	64	63	63	62	61	61	60	59
1.9	59	59	58	58	57	56	56	55	55	54

$\bar{\lambda}_s$ (κ_2)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.1	330	330	330	330	330	330	330	330	328	324
0.2	319	315	310	306	302	297	293	288	284	280
0.3	275	271	266	262	257	253	249	245	241	237
0.4	233	230	226	223	219	216	212	209	206	203
0.5	200	198	194	191	188	186	183	180	178	175
0.6	171	170	167	165	163	160	158	156	153	151
0.7	149	147	145	142	140	138	136	134	132	130
0.8	128	127	125	123	121	119	118	116	114	112
0.9	111	109	107	106	104	103	101	100	98	97
1.0	95	94	93	91	90	88	87	86	85	83
1.1	82	81	80	78	77	76	75	74	73	72
1.2	71	70	69	68	67	66	65	64	63	62
1.3	61	60	59	59	58	58	57	56	55	54

$\bar{\lambda}_s$ (κ_1)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	355	355	355	355	355	355	355	355	355	355
0.1	355	355	355	355	355	355	355	355	355	355
0.2	355	355	355	355	355	355	355	355	353	350
0.3	347	343	340	336	333	330	326	323	319	316
0.4	313	309	306	302	299	296	292	289	285	282
0.5	279	275	272	269	266	263	260	257	254	251
0.6	249	246	243	241	238	235	233	230	228	225
0.7	223	221	218	216	214	211	209	207	205	202
0.8	200	198	196	194	192	190	188	186	184	182
0.9	180	178	177	175	173	171	169	167	166	164
1.0	162	161	159	157	156	154	152	151	149	148
1.1	146	144	143	141	140	138	137	136	134	133
1.2	131	130	129	127	126	124	123	122	121	119
1.3	118	117	115	114	113	112	111	109	108	107
1.4	106	105	104	103	102	100	99	98	97	96
1.5	95	94	93	92	91	90	89	88	87	96
1.6	86	85	84	83	82	81	80	79	79	78
1.7	77	76	75	75	74	73	72	72	71	70
1.8	70	69	68	67	67	66	65	65	64	64
1.9	64	63	63	62	61	61	60	59	59	58

$\bar{\lambda}_s$ (κ_2)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.1	355	355	355	355	355	355	355	355	354	350
0.2	345	340	336	331	326	322	317	313	308	303
0.3	299	294	289	284	280	275	270	266	262	258
0.4	253	249	246	242	238	234	231	227	224	220
0.5	217	214	211	207	206	201	195	195	193	190
0.6	187	184	181	179	176	174	171	169	166	164
0.7	161	159	157	154	152	150	148	145	143	141
0.8	139	137	135	133	131	129	127	125	123	122
0.9	120	118	116	114	113	111	109	108	106	105
1.0	103	101	100	98	97	95	94	93	91	90
1.1	89	87	86	85	83	82	81	80	79	77
1.2	76	75	74	73	72	71	70	69	68	67
1.3	66	65	64	64	63	62	61	60	59	59

$\bar{\lambda}_s$ (κ_1)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	420	420	420	420	420	420	420	420	420	420
0.1	420	420	420	420	420	420	420	420	420	420
0.2	420	420	420	420	420	420	420	420	420	420
0.3	419	415	411	407	403	399	396	392	388	384
0.4	380	376	362	368	365	361	357	353	349	345
0.5	341	337	334	330	326	322	318	315	311	308
0.6	304	301	297	294	291	288	284	281	278	275
0.7	272	269	266	263	261	258	255	252	250	247
0.8	244	242	239	236	234	231	229	227	224	222
0.9	219	217	215	212	210	208	206	204	201	199
1.0	197	195	193	191	189	187	185	183	181	179
1.1	177	175	173	171	170	168	166	164	162	161
1.2	159	157	155	154	152	150	149	147	146	144
1.3	143	141	139	138	136	135	133	132	131	129
1.4	128	126	125	124	122	121	120	118	117	116
1.5	115	113	112	111	110	108	107	106	105	104
1.6	103	102	101	99	98	97	96	95	94	93
1.7	92	91	90	89	89	88	87	86	85	84
1.8	83	836	82	81	80	79	78	77	77	76
1.9	76	75	74	73	73	72	71	70	70	69

$\bar{\lambda}_s$ (κ_2)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.1	420	420	420	420	420	420	420	420	420	418
0.2	412	407	402	397	391	386	381	376	370	365
0.3	360	351	349	344	339	333	328	322	317	312
0.4	307	302	297	292	288	283	279	275	270	266
0.5	265	258	254	250	247	243	239	236	232	229
0.6	225	222	219	215	212	209	206	203	200	197
0.7	194	191	188	185	182	180	177	174	172	169
0.8	167	164	162	159	157	155	152	150	148	145
0.9	143	141	139	137	135	133	131	129	127	125
1.0	123	121	119	117	115	114	112	110	109	107
1.1	105	104	102	101	99	98	96	95	93	92
1.2	90	89	88	87	85	84	83	82	80	79
1.3	78	77	76	75	74	73	72	71	70	69

$\bar{\lambda}_s$ (κ_1)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	460	460	460	460	460	460	460	460	460	460
0.1	460	460	460	460	460	460	460	460	460	460
0.2	460	460	460	460	460	460	460	460	460	460
0.3	460	457	453	449	445	440	436	432	428	424
0.4	420	415	411	407	403	399	395	390	386	382
0.5	378	374	370	365	361	357	353	349	345	341
0.6	337	333	330	326	322	319	315	312	308	305
0.7	302	298	295	292	289	285	282	279	276	273
0.8	270	267	264	262	259	256	253	251	248	245
0.9	243	240	237	235	232	230	227	225	222	220
1.0	218	215	213	211	208	206	204	202	200	197
1.1	195	193	191	189	187	185	183	181	179	177
1.2	175	173	171	169	168	166	164	162	160	159
1.3	157	155	154	152	150	149	147	145	144	142
1.4	141	139	137	136	134	133	132	130	129	127
1.5	126	124	123	122	120	119	118	117	115	114
1.6	113	112	110	109	108	107	016	105	103	102
1.7	101	100	99	98	97	96	95	94	93	92
1.8	91	91	89	89	88	87	86	85	84	83
1.9	83	82	81	80	79	79	78	77	76	76

$\bar{\lambda}_s$ (κ_2)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.1	460	460	460	460	460	460	460	460	460	460
0.2	454	448	443	437	431	426	420	414	409	403
0.3	397	392	386	380	375	369	363	357	351	346
0.4	340	335	329	324	319	314	309	304	300	295
0.5	290	286	282	277	273	269	265	261	257	253
0.6	249	245	242	238	235	231	228	224	221	217
0.7	214	211	208	205	201	198	195	192	190	187
0.8	184	181	178	176	173	170	168	165	163	160
0.9	158	155	153	151	148	146	144	141	139	137
1.0	135	133	131	129	127	125	123	121	119	117
1.1	116	114	112	110	109	107	105	104	102	101
1.2	99	98	96	95	94	92	91	89	88	87
1.3	86	84	83	82	81	80	79	78	77	76

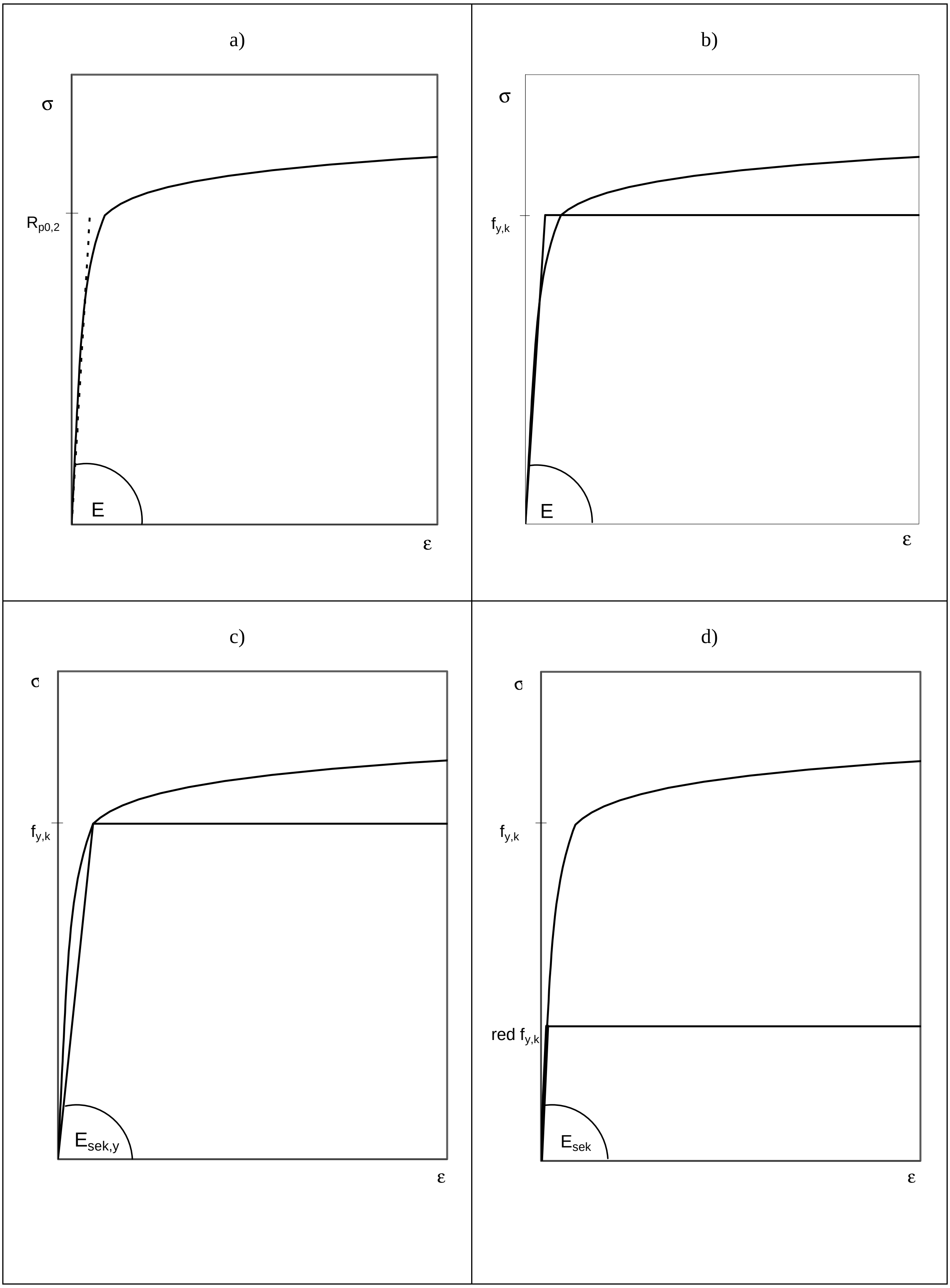

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Figure 1 stress-strain curves for stainless steels

a reality with non-linear elastic range approximated by power law

b,c,d bi-linear approximation

Annex 14

to *allgemeinen bauaufsichtlichen Zulassung*

Z-30.3-6

of 20 April 2009

$\bar{\lambda}_k$	buckling stress curve a									
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.4	1.00	1.00	1.00	1.00	1.00	0.99	0.98	0.97	0.96	0.95
0.5	0.95	0.94	0.93	0.92	0.92	0.91	0.90	0.90	0.89	0.88
0.6	0.88	0.87	0.86	0.86	0.86	0.85	0.85	0.84	0.83	0.82
0.7	0.82	0.81	0.81	0.81	0.80	0.80	0.79	0.79	0.78	0.78
0.8	0.77	0.77	0.76	0.76	0.75	0.75	0.75	0.74	0.74	0.73
0.9	0.73	0.72	0.72	0.72	0.71	0.71	0.70	0.70	0.70	0.69
1.0	0.69	0.69	0.68	0.68	0.67	0.67	0.67	0.66	0.66	0.66
1.1	0.65	0.65	0.65	0.64	0.64	0.64	0.64	0.63	0.63	0.63
1.2	0.62	0.62	0.62	0.62	0.61	0.61	0.61	0.61	0.60	0.60
1.3	0.60	0.60	0.59	0.59	0.59	0.59	0.58	0.58	0.58	0.58
1.4	0.57	0.57	0.57	0.57	0.56	0.56	0.56	0.56	0.56	0.55
1.5	0.55	0.55	0.55	0.54	0.54	0.54	0.54	0.54	0.53	0.53
1.6	0.53	0.53	0.53	0.53	0.52	0.52	0.52	0.52	0.52	0.52
1.7	0.52	0.51	0.51	0.51	0.51	0.51	0.51	0.50	0.50	0.50
1.8	0.50	0.50	0.50	0.49	0.49	0.49	0.49	0.49	0.49	0.49
1.9	0.49	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.47	0.47
2.0	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.46	0.46	0.46
2.1	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.45	0.45	0.45
2.2	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.44	0.44	0.44
2.3	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.43
2.5	0.43	0.43	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
2.6	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.41	0.41	0.41
2.8	0.41	0.41	0.41	0.40	0.40	0.40	0.40	0.40	0.40	0.40

	buckling stress curve b									
$\bar{\lambda}_k$	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.4	1.00	0.99	0.98	0.97	0.96	0.95	0.94	0.94	0.93	0.92
0.5	0.91	0.91	0.90	0.89	0.89	0.88	0.87	0.87	0.86	0.86
0.6	0.85	0.84	0.84	0.83	0.83	0.82	0.82	0.81	0.81	0.80
0.7	0.80	0.79	0.79	0.79	0.78	0.78	0.77	0.77	0.76	0.76
0.8	0.76	0.75	0.75	0.74	0.74	0.74	0.73	0.73	0.72	0.72
0.9	0.72	0.71	0.71	0.71	0.70	0.70	0.70	0.69	0.69	0.69
1.0	0.68	0.68	0.68	0.67	0.67	0.67	0.66	0.66	0.66	0.65
1.1	0.65	0.65	0.65	0.64	0.64	0.64	0.63	0.63	0.63	0.63
1.2	0.62	0.62	0.62	0.62	0.62	0.61	0.61	0.61	0.61	0.60
1.3	0.60	0.60	0.60	0.60	0.59	0.59	0.59	0.59	0.58	0.58
1.4	0.58	0.58	0.58	0.57	0.57	0.57	0.57	0.57	0.57	0.56
1.5	0.56	0.56	0.56	0.56	0.55	0.55	0.55	0.55	0.55	0.55
1.6	0.54	0.54	0.54	0.54	0.54	0.54	0.53	0.53	0.53	0.53
1.7	0.53	0.53	0.53	0.53	0.52	0.52	0.52	0.52	0.52	0.52
1.8	0.52	0.52	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51
1.9	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.49	0.49
2.0	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.48	0.48
2.1	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.47
2.3	0.47	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
2.4	0.46	0.46	0.46	0.46	0.45	0.45	0.45	0.45	0.45	0.45
2.5	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.44	0.44
2.7	0.44	0.44	0.44	0.44	0.44	0.44	0.43	0.43	0.43	0.43
2.9	0.43	0.43	0.43	0.43	0.43	0.42	0.42	0.42	0.42	0.42
3.1	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.41	0.41	0.41
3.4	0.41	0.41	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40

	buckling stress curve c									
$\bar{\lambda}_k$	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.98	0.97
0.4	0.96	0.95	0.94	0.94	0.93	0.92	0.91	0.91	0.90	0.89
0.5	0.89	0.88	0.87	0.87	0.86	0.85	0.85	0.84	0.84	0.83
0.6	0.83	0.82	0.82	0.81	0.81	0.80	0.80	0.79	0.79	0.78
0.7	0.78	0.77	0.77	0.77	0.76	0.76	0.76	0.75	0.75	0.75
0.8	0.74	0.74	0.73	0.73	0.73	0.72	0.72	0.72	0.71	0.71
0.9	0.71	0.70	0.70	0.70	0.69	0.69	0.69	0.68	0.68	0.68
1.0	0.68	0.67	0.67	0.67	0.66	0.66	0.66	0.66	0.65	0.65
1.1	0.65	0.65	0.64	0.64	0.64	0.64	0.63	0.63	0.63	0.63
1.2	0.63	0.62	0.62	0.62	0.62	0.62	0.61	0.61	0.61	0.61
1.3	0.61	0.60	0.60	0.60	0.60	0.60	0.59	0.59	0.59	0.59
1.4	0.59	0.58	0.58	0.58	0.58	0.58	0.58	0.57	0.57	0.57
1.5	0.57	0.57	0.57	0.56	0.56	0.56	0.56	0.56	0.56	0.56
1.6	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.54	0.54	0.54
1.7	0.54	0.54	0.54	0.54	0.54	0.54	0.53	0.53	0.53	0.53
1.8	0.53	0.53	0.53	0.53	0.52	0.52	0.52	0.52	0.52	0.52
1.9	0.52	0.52	0.52	0.51	0.51	0.51	0.51	0.51	0.51	0.51
2.0	0.51	0.51	0.51	0.50	0.50	0.50	0.50	0.50	0.50	0.50
2.1	0.50	0.50	0.50	0.50	0.49	0.49	0.49	0.49	0.49	0.49
2.2	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.48
2.4	0.48	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47
2.5	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.46	0.46	0.46
2.7	0.46	0.46	0.46	0.46	0.46	0.45	0.45	0.45	0.45	0.45
2.9	0.45	0.45	0.45	0.45	0.45	0.44	0.44	0.44	0.44	0.44
3.1	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.43
3.4	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.42	0.42	0.42
3.7	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.41	0.41
4.1	0.41	0.41	0.41	0.41	0.41	0.40	0.40	0.40	0.40	0.40

	buckling stress curve d									
$\bar{\lambda}_k$	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.3	1.00	0.99	0.98	0.97	0.96	0.95	0.94	0.94	0.93	0.92
0.4	0.91	0.90	0.90	0.89	0.88	0.88	0.87	0.86	0.86	0.85
0.5	0.85	0.84	0.83	0.83	0.82	0.82	0.81	0.81	0.80	0.80
0.6	0.79	0.79	0.79	0.78	0.78	0.77	0.77	0.77	0.76	0.76
0.7	0.75	0.75	0.75	0.75	0.74	0.74	0.74	0.73	0.73	0.73
0.8	0.72	0.72	0.72	0.71	0.71	0.71	0.70	0.70	0.70	0.69
0.9	0.69	0.69	0.69	0.68	0.68	0.68	0.68	0.67	0.67	0.67
1.0	0.67	0.66	0.66	0.66	0.66	0.65	0.65	0.65	0.65	0.65
1.1	0.64	0.64	0.64	0.64	0.64	0.63	0.63	0.63	0.63	0.63
1.2	0.63	0.62	0.62	0.62	0.62	0.62	0.61	0.61	0.61	0.61
1.3	0.61	0.61	0.60	0.60	0.60	0.60	0.60	0.60	0.59	0.59
1.4	0.59	0.59	0.59	0.59	0.59	0.58	0.58	0.58	0.58	0.58
1.5	0.58	0.58	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57
1.6	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56
1.7	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.54
1.8	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.53
1.9	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53
2.0	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52
2.1	0.52	0.52	0.52	0.51	0.51	0.51	0.51	0.51	0.51	0.51
2.2	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.50	0.50
2.4	0.50	0.50	0.50	0.50	0.49	0.49	0.49	0.49	0.49	0.49
2.6	0.49	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
2.8	0.48	0.48	0.48	0.47	0.47	0.47	0.47	0.47	0.47	0.47
3.0	0.47	0.47	0.47	0.47	0.47	0.47	0.46	0.46	0.46	0.46
3.3	0.46	0.46	0.46	0.45	0.45	0.45	0.45	0.45	0.45	0.45
3.6	0.45	0.45	0.45	0.45	0.45	0.44	0.44	0.44	0.44	0.44
4.0	0.44	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43
4.4	0.43	0.43	0.43	0.43	0.43	0.42	0.42	0.42	0.42	0.42
4.9	0.42	0.42	0.42	0.42	0.42	0.42	0.41	0.41	0.41	0.41
5.0	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41

$f_{y,k}$ = 190	member factor n						
$\bar{\lambda}_M$	1.17	1.03	0.92	0.89	0.80	0.77	0.64
0.2	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0.4	1.00	1.00	1.00	1.00	0.98	0.97	0.95
0.6	0.91	0.89	0.87	0.86	0.85	0.84	0.83
0.8	0.79	0.78	0.77	0.77	0.76	0.76	0.75
1.0	0.71	0.70	0.70	0.70	0.70	0.70	0.69
1.2	0.64	0.64	0.65	0.65	0.65	0.65	0.65
1.4	0.58	0.59	0.60	0.60	0.61	0.61	0.62
1.6	0.54	0.55	0.57	0.57	0.58	0.58	0.59
1.8	0.50	0.52	0.54	0.54	0.55	0.56	0.57
2.0	0.47	0.49	0.51	0.52	0.53	0.54	0.55
2.2	0.44	0.46	0.49	0.49	0.51	0.52	0.53
2.4	0.41	0.44	0.47	0.47	0.49	0.50	0.52
2.6	(0.39)	0.42	0.45	0.46	0.48	0.48	0.50
2.8	(0.37)	(0.40)	0.43	0.44	0.46	0.47	0.49
3.0	(0.36)	(0.39)	0.42	0.43	0.45	0.46	0.48
3.2	(0.34)	(0.38)	0.41	0.42	0.44	0.45	0.47
3.4	(0.33)	(0.36)	(0.40)	0.41	0.43	0.44	0.46
3.6	(0.32)	(0.35)	(0.39)	(0.39)	0.42	0.43	0.45

$f_{y,k}$ = 460	member factor n						
$\bar{\lambda}_M$	1.17	1.03	0.92	0.89	0.80	0.77	0.64
0.4	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0.6	1.00	1.00	1.00	0.99	0.98	0.97	0.96
0.8	0.91	0.90	0.89	0.88	0.88	0.87	0.87
1.0	0.80	0.80	0.80	0.80	0.80	0.80	0.80
1.2	0.72	0.73	0.74	0.74	0.75	0.75	0.76
1.4	0.66	0.67	0.69	0.69	0.70	0.71	0.72
1.6	0.61	0.63	0.65	0.65	0.67	0.67	0.69
1.8	0.56	0.59	0.61	0.62	0.64	0.64	0.66
2.0	0.53	0.56	0.58	0.59	0.61	0.62	0.64
2.2	0.49	0.53	0.56	0.57	0.59	0.60	0.62
2.4	0.47	0.50	0.54	0.54	0.57	0.58	0.60
2.6	0.44	0.48	0.51	0.53	0.55	0.56	0.58
2.8	0.42	0.46	0.50	0.51	0.53	0.54	0.57
3.0	(0.40)	0.44	0.48	0.49	0.52	0.53	0.55
3.2	(0.39)	0.43	0.47	0.48	0.50	0.52	0.54
3.4	(0.37)	0.41	0.45	0.46	0.49	0.50	0.53
3.6	(0.36)	(0.40)	0.44	0.45	0.48	0.49	0.52

The yield strength reduction factor ρ_f = red $f_{y,k}/f_{y,k}$ basic for the calculation of the reduction factor κ_M are given in both Tables. For the bracketed values the calculation according to section 3.3.2.3.2(1) may be executed with 0.40 $f_{y,k}$ instead of $f_{y,k}$ and E = 170,000 N/mm^2 according to DIN 18800-2:2008-11 without further modifications.

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Manufacturer of products according to Annex 1 Table 1 (informative)

Annex 16
to *allgemeinen bauaufsichtlichen Zulassung*
Z-30.3-6
of 20 April 2009

The delivery of the cross marked products requires to full fill the specific provisions to the verification of conformity of this national technical approval.

Company		**Plate**	**Strip**		**Long products[1]**		**Wire**		**Sections[2]**	**Hollow sections (pipes)**	**Fastening elements dowels**
Name	**Postcode/Location Internet**		**cold rolled**	**hot rolled**	**rolled**	**drawn (bright steel)**	**rolled**	**drawn**			
ArcelorMittal – Stainless Europe	F-93212 La Plaine Saint-Denis www.arcelormittal.com/stainlesseurope	X	X	X							
Cogne Acciai Speciali SPA	I-11100 Aosta www.cogne.com				X	X	X				
Deutsche Edelstahlwerke GmbH	D-57078 Siegen www.dew-stahl.com				X	X	X	X			
Hagener Feinstahl GmbH	D-58089 Hagen www.hagener-feinstahl.de					X	X	X			
Hempel Special Metals GmbH	D-46149 Oberhausen www.hempel-metals.com						X	X	X		X
Hoesch Schwerter Profile GmbH	D-58239 Schwerte www.hoesch-profile.com				X	X			X	X	
Mannstaedt GmbH	D-53840 Troisdorf www.mannstaedt.de				X				X		
Wilhelm Modersohn GmbH & Co. KG	D-32139 Spenge www.modersohn.de								X	X	X
Montanstahl AG	CH-6855 Stabio www.montanstahl.com				X	X			X		
Aceros Inoxidables OLARRA S.A.	E-48080 Bilbao www.olarra.com				X	X	X		X		
Outokumpu GmbH	D-47877 Willich www.outokumpu.com	X	X	X						X	
Stalatube O	FIN-15170 Lahti www.stalatube.com									X	
ThyssenKrupp Nirosta GmbH	D-47807 Krefeld www.nirosta.de	X	X	X							
ThyssenKrupp VDM GmbH	D-58751 Werdohl www.thyssenkruppvdm.de	X	X	X	X	X	X	X			
UGITECH GmbH	D-71272 Renningen www.ugitech.com				X	X	X	X	X		
Wagener & Simon WASI GmbH & Co. KG	D-42289 Wuppertal www.wasi.de										X
Walzwerke Einsal GmbH	D-58769 Nachrodt www.walzwerke-einsal.de				X	X		X	X		

1) forged long products as well

2) hot rolled as well as cut profiles, edged/bended profiles, laser beam welded profiles and hot extruded special profiles made of hot rolled

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