

## Allgemeine bauaufsichtliche Zulassung

Zulassungsstelle für Bauprodukte und Bauarten

Bautechnisches Prüfamt

Eine vom Bund und den Ländern  
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In case of doubt, the German-language original shall be considered authoritative.

Approval number:

**Z-30.3-6**

Validity

from: **1 May 2014**

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Applicant:

Informationsstelle Edelstahl Rostfrei

Sohnstrasse 65

40237 Düsseldorf

Subject of approval:

**Products, fasteners and structural components 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 31 pages<sup>\*)</sup> and 33 Annexes.

This *allgemeine bauaufsichtliche Zulassung* ('national technical approval') replaces the *allgemeine bauaufsichtliche Zulassung* ('national technical approval') Z-30.3-6 of 20 April 2009 amended by notification, dated 2 May 2011. An *allgemeine bauaufsichtliche Zulassung* ('national technical approval') was granted for this construction product for the first time on 31 May 1974.

<sup>\*)</sup> The number of pages refers to the original approval

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**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 clause 17, sub-clause 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.
- 3 The *allgemeine bauaufsichtliche Zulassung* ('national technical approval') does not replace the permits, approvals and certificates prescribed by law for carrying out building projects.
- 4 The *allgemeine bauaufsichtliche Zulassung* ('national technical approval') will be granted without prejudice to the rights of third parties, in particular private property rights.
- 5 Notwithstanding further regulations in the "Specific Provisions" manufacturers and distributors of the subject of approval shall make copies of the *allgemeine bauaufsichtliche Zulassung* ('national technical approval') available to the user and point out that the *allgemeine bauaufsichtliche Zulassung* ('national technical approval') has to be available at the place of use. Upon request copies of the *allgemeine bauaufsichtliche Zulassung* ('national technical approval') shall be placed at the disposal of the authorities involved.
- 6 The *allgemeine bauaufsichtliche Zulassung* ('national technical approval') may be reproduced in full only. Publication in the form of extracts requires the consent of *Deutsches Institut für Bautechnik*. Texts and drawings of advertising brochures may not be in contradiction to the *allgemeine bauaufsichtliche Zulassung* ('national technical approval'). Translations of the *allgemeine bauaufsichtliche Zulassung* ('national technical approval') have to contain the note "Translation of the German original, not checked by *Deutsches Institut für Bautechnik*".
- 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.

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## **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 E DIN EN 10088-1:2012-01<sup>1)</sup> as well as structural components and their connections produced from them.

<sup>1)</sup> As far as the new issue of DIN EN 10088-1 is available it shall be applied instead of E DIN EN 10088-1:2012-01.

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

Note: The classification of cold-worked steels into the strength classes S235 to S690 in this *allgemeine bauaufsichtliche Zulassung* ('national technical approval') deviates regarding designation and amount from the provisions in the standards of the series of standards DIN EN 10088.

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/cm<sup>2</sup> according to the tensile strengths  $R_m$ .

Structural 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 components 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

or as far as relevant according to the appropriate standards of the series of standards DIN EN 1993 or DIN EN 1994, each in connection with the National Annex.

#### **1.2 Field of application**

This national technical approval applies to structural components and connections under predominantly static loads and atmospheric conditions.

For façade components and their anchoring elements and fasteners, clause 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 five corrosion resistance classes; see Annex 1, Table 1. The selected corrosion resistance classes shall fulfill the requirements put on the structural components for corrosion protection, also with regard to the time of protection.

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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, 1.4062, 1.4162, 1.4362, 1.4462 and 1.4662, a sufficient notched-bar impact energy with ISO-V-specimen 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. The maximum nominal diameters of the fasteners in connection with the steel grades and strength classes are listed in Annex 2, Table 2.

**2.1.2 Technical delivery conditions for products according to Table 1, 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,
- Fpr EN 10088-2:2014<sup>1,2)</sup> for sheet/plate and strip,
- E DIN EN 10088-3:2012-01<sup>1,2)</sup> for bars, rods, wire and sections,
- DIN EN 10296-2:2006-02 for welded tubes,
- DIN EN 10297-2:2006-02 for seamless tubes.

<sup>1)</sup> As far as the new issue of the standard (DIN EN) is available it shall be applied instead of the draft.

<sup>2)</sup> Does only apply to the steel grades with the material numbers 1.4062 and 1.4662.

**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 clause 2.1.2.1 for the condition 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 energy. Since austenitic stainless steels are not susceptible to brittle fracture up to temperatures of -40 °C, they 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 1.4062, 1.4162, 1.4362, 1.4462 and 1.4662 at least one notched-bar impact energy of 40 J with ISO-V-specimen shall be proven at -40 °C. For long products the proof shall be furnished on longitudinal specimen and for flat products on transverse specimen. The value of the notched-bar impact work is determined as mean value of 3 specimen, 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 bolts and threaded rods,
- DIN EN ISO 3506-2:2010-04 for nuts, and as far as applicable, also for washers.

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### **2.1.4 Suitability for welding; welding consumables**

#### 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 steel grades are approved for the following welding processes:

Manual metal arc welding (111), TIG welding (141), MIG welding (131), MIG welding (135), MAG welding with flux cored electrode (136), submerged arc welding (12), drawn arc stud welding (783), 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 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 structural components made of the same stainless steel grades according to this national technical approval, such joints of structural components made of different steel grades - hereafter named mixed joints - are allowable. It may concern structural components made of:

- different stainless steel grades according to this national technical approval
- stainless steel grades according to this national technical approval and weldable carbon steels according to DIN EN 1993-1-1:2010-12 and DIN EN 1993-1-12:2010-12 each in connection with the National Annex as well as according to national technical approval, European Technical Approval or European Technical Assessment.

(2) Welding consumables for joints of structural 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 structural 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 structural 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 EN 1993-1-1:2010-12 and DIN EN 1993-1-12:2010-12 each in connection with the National Annex as well as according to national technical approval, European Technical Approval or European Technical Assessment. 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 °C shall be avoided. Incidentally, DIN EN 1011- 2:2009-07 shall be taken into account for fine grain steels.

(6) In mixed joints of structural components made of austenitic-ferritic steel grades with the material numbers 1.4062, 1.4162, 1.4362, 1.4462 and 1.4662 on the one hand and structural components made of carbon steels according to DIN EN 1993-1-1:2010-12 and DIN EN 1993-1-12:2010-12 each in connection with the National Annex as well as according to national technical approval, European Technical Approval or European Technical Assessment. On the other hand, the filler metal given for the steel grades with the material numbers 1.4062, 1.4162, 1.4362, 1.4462 and 1.4662 in Annex 4 shall be preferred. The filler metals according to Annex 5, Table 7 may also be used. Paragraph (5) applies for thermal conduction.

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### **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 clauses of this national technical approval, to the maximum thicknesses apply

- the specifications in DIN EN 10088-4:2010-01 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 steel grades 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 clause 2.3.

### **2.1.6 Corrosion protection of the construction products**

#### 2.1.6.1 Requirements

(1) For reasons of stability, structural 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 1.1,
- no deviating requirements result from clauses 2.1.6.2 to 2.1.6.7 and
- the requirements regarding service and maintenance according clause 5.2 are met.

Note:

Corrosion resistance classes integrate different alloys showing a comparable corrosion resistance under the same corrosion loads. The selection of materials according to Table 1.1 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 structural 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 structural 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) To ensure the corrosion protection, a post-treatment of the cutting edge and the welds is necessary to remove annealing colours. Welds shall be constructionally 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

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corrosion causing media can be safely excluded. The appropriate mounting situation shall be specified.

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.

Note: 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 clause 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 clause 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).

Note: 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, hygroscopic or constantly damp deposits, self-sucking sealings or constantly damp 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, e.g. 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 structural components made of stainless steels is not permitted. When coming into contact of stainless steel with molten zinc which may occur upon hot-dip galvanizing - i.e. of structural components with mixed joints - or in the event of fire, the risk of

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an immediate embrittlement exists. This contact shall not be excluded if the stability of the load-bearing structure is not jeopardized through an embrittlement of the stainless steel.

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

Welded joints and other metallicly 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 construction products**

### **2.2.1 Package, transport, storage**

The products and fasteners as well as the structural components produced from them 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 permitted if the conditions given in clause 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, clause 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 bolting assemblies for bolted connections consisting of bolts according to DIN EN ISO 3506-1:2010-04, nuts according to DIN EN ISO 3506-2:2010-04 and, if necessary washers DIN EN 15048-1:2007-07, Annex ZA applies.

Bolting assemblies where dimensions and materials are not included in DIN EN ISO 3506-1 or -2:2010-04 (e. g. > M39) as well as single components of bolting assemblies, like bolts or nuts (e.g. nuts on threaded bars) and 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 permitted if the conditions given in clause 2.3 are satisfied. Furthermore the fasteners shall be marked with the steel name or steel number according to the delivery conditions in clause 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.



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### 2.2.2.3 Structural components

The delivery notes or other accompanying papers of the structural components 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. Marking is only permitted if the conditions given in clause 2.3 are satisfied.

## **2.3 Verification of conformity**

### **2.3.1 General**

#### 2.3.1.1 Products and Fasteners

(1) The following provisions of clause 2.3 apply to the products and fasteners marked with the mark of conformity (*Ü-Zeichen*) ('Ü-mark') according to clause 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*. Additionally a copy of the initial type testing report shall be submitted to the *Deutsches Institut für Bautechnik* for information.

#### 2.3.1.2 Structural components

Proof of conformity of the structural components with the provisions of this national technical approval, shall be delivered by means of a certificate of conformity by the manufacturer issued for each manufacturing plant and based on an initial-type testing by the manufacturer and a factory production control.

The declaration of conformity shall be given by the manufacturer by marking the delivery notes or other accompanying papers with the mark of conformity (*Ü-Zeichen*) ('Ü-mark') stating the intended use.

### **2.3.2 Factory production control of the construction products**

(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 specimen the technical delivery conditions for products of corrosion resisting steels according to clause 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 3506-2:2010-04 applies.

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.

DIN 18800-7:2008-11 shall be additionally taken into account for structural components.

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(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 structural components
- type of control or testing,
- date of manufacture and date of testing of the construction product or the initial materials and the structural components,
- results of control and testing 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 of products and fasteners**

(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, 1.4062, 1.4162, 1.4362, 1.4462 and 1.4662 at least one set (3 specimen) 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 clause 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.

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**3 Provisions for the design and structural analysis of structural components and joints**

**3.1 General**

**3.1.1 Technical rules to be applied**

DIN 18800-1 to 4:2008-11 in connection with the appropriate engineering standards applies, unless other provisions are stated following behind. The provisions concerning the design and structural analyses in clause 4 of this national technical approval shall be taken into account as well.

**3.1.2 Different steel grades in a structure**

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

If different steel grades are used in a 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 Structural 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 clause 2.1.6.

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

**3.2.2 Welded joints**

**3.2.2.1 Limitation of weld thicknesses**

(1) For welded joints of structural 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  $1.5 \text{ mm} \leq t < 2 \text{ mm}$ , 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 clause 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 structural components, since with a higher cold forming and an additional heating, a grain growth with loss of ductility may occur.

### 3.3 Structural analyses

#### 3.3.1 Characteristic values of mechanical properties for verifications of ultimate limit state 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 Annexes 8.1 and 8.2, Table 11 apply.

(2) For calculations according to the theory of second order and other verifications 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 conditions of the steel grades

- 1.4003, 1.4016, 1.4567, 1.4318, 1.4578, 1.4439, 1.4062, 1.4162, 1.4362, 1.4462, 1.4662, 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 355 N/mm<sup>2</sup> 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 conditions 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 verification 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  $\varepsilon$  depend non-linearly on the stresses (Fig. 1a in Annex 14). They can be specified through the power law

$$\varepsilon = \frac{\sigma}{E} + 0.002 \cdot \left[ \frac{\sigma}{f_{y,k}} \right]^n$$

where

$n = 6$  for  $\sigma \leq f_{y,k}$

$n = 17$  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 verifications may be based upon a linear elastic perfect plastic stress-strain relation according to the clauses 3.3.2.2 or 3.3.2.3.2.

##### 3.3.2.2 Stress-strain relation for verifications 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.

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3.3.2.3 Stress and strain relation for verifications 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

$$\varepsilon = \frac{\sigma}{E} + 0.002 \cdot \left[ \frac{\sigma}{f_{y,k}} \right]^n$$

where

$n = 6$  for  $\sigma \leq f_{y,k}$

and for

$$\varepsilon > \frac{f_{y,d}}{E} + 0.002 \cdot \left[ \frac{f_{y,d}}{f_{y,k}} \right]^n$$

$\sigma = f_{y,k}$  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 relation may be assumed either

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

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

$$E_{\text{sek}} = \frac{E}{1 + 0.002 \cdot \frac{E}{f_{y,k}} \cdot \rho_f^5} \quad \text{and} \quad E_{\text{sek},y} = \frac{E}{1 + 0.002 \cdot \frac{E}{f_{y,k}}}$$

where

$\rho_f$  yield strength reduction factor

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

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

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

where

$\sigma_v$  effective stress according to DIN 18800-1:2008-11, formula (36) may be freely selected.

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

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Note 1:

The second condition corresponds to the verification 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

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

applies.

Note 3:

Note on the determination of the yield strength reduction factor  $\rho_f$

- If the effective strength  $\sigma_v$  is known, then  $\rho_f$  follows from:

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

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

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

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

and

$$\mu = 0.3$$

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

With regard to the variables  $E_{\text{sek}}$ ,  $G_{\text{sek}}$  and  $\text{red } f_{y,k}$  or in the special case according to Fig.1c in Annex 14, the variables  $E_{\text{sek},y}$  and  $G_{\text{sek},y}$  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  $E_{\text{sek}} > E_{\text{sek},y}$  is assumed, thus  $\rho_f < 1$ , for the stress-strain relations, all verifications shall be furnished with  $\text{red } f_{y,d}$ .

**3.3.3 Delimitation criteria**

For verifications according to DIN 18800-1:2008-11, elements 728, 739 and 740, the secant modulus  $E_{\text{sek},y}$  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.

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**3.3.4 Fatigue strength**

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

$$\Delta\sigma < 21 \text{ N/mm}^2 \quad \text{for (25)}$$

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

**3.3.5 Verifications 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 formulas (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 verification is to be furnished independent on the bearing stress verification element (805) in DIN 18800-1:2008-11. The verification whether the deduction of holes may be disregarded, shall be furnished using formula (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

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

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

and  $E_{\text{Baustahl}} = 210000 \text{ N/mm}^2$  ( $E_{\text{Baustahl}} = E_{\text{carbon steel}}$ )

**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

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

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

and  $E_{\text{Baustahl}} = 210000 \text{ N/mm}^2$

**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 clause 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 Resistance of bolts 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  $\alpha_a$  in formula (47):

$\alpha_a = 0.75$  for bolts of strength class 50,

$\alpha_a = 0.68$  for bolts of strength class 70 and 80.

The steel grades with the serial number 12 to 20 according to Table 2 apply uniformly to  $\alpha_a = 0.5$  for bolts of the strength classes 50, 70 and 80.

The verification 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 bolts may show locally different mechanical properties in contrast to bolts made of non-alloy or low-alloy steel.

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**3.3.5.7 Resistance of bolts on tension**

Deviating from element (506) in DIN 18800-1:2008-11 bolts, nuts and washers  $\geq M6$  and  $< M12$  may be used with an utilization for tension of  $\leq 70\%$  as long as the nominal clearance is  $\Delta d \leq 0,5$  mm.

**3.3.5.8 Resistance of weld joints**

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

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 lower 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, is to be set for  $f_{y,k}$ . In addition, the verification 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 mixed joints according to Table 6 and 7.

3) For the  $\alpha_w$ -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 joints to Table 6 and 7, the  $\alpha_w$ -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 verification 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 Verifications according to DIN 18800-2, -3 and -4:2008-11**

**3.3.6.1 Basics on the verification of safety against instable failure**

**3.3.6.1.1 Stress-strain relation**

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

$f_{y,k}$  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 verification corresponding to clause 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 are:

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

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



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

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

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

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

3.3.6.1.2 Simplified verifications

For the stability cases flexural buckling, lateral torsional buckling and plate buckling,  $\kappa$ -values for stainless steels are indicated in clauses 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 clause 3.3.7.10. In these  $\kappa$ -values, the non-linear material behavior is taken into account.

Therefore, a simplified verification with  $E = 170000 \text{ N/mm}^2$  and  $f_{y,k}$  according to clause 3.3.1.1(2) can be furnished in the mentioned cases.

**3.3.7 Verifications according to DIN 18800-2:2008-11**

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

The verifications may be furnished according to DIN 18800-2:2008-11, clause 3, considering the definition in the following clauses 3.3.7.2 to 3.3.7.9 using  $E = 170000 \text{ N/mm}^2$  and  $f_{y,k}$  according to clause 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 3<sup>rd</sup> dash is not to be applied here.

3.3.7.3 Reduction factor  $\kappa$  for verifications of flexural buckling

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

$$\bar{\lambda}_{\kappa} \leq 0.13: \quad \kappa = 1 \quad \text{for (4a)}$$

$$\bar{\lambda}_{\kappa} > 0.13: \quad \kappa = \frac{1}{k + \sqrt{k^2 - \bar{\lambda}_{\kappa}^2}} \quad \text{for (4b)}$$

$$k = 0.5 \cdot [1 + \alpha \cdot (\bar{\lambda}_{\kappa} - 0.13) + \bar{\lambda}_{\kappa}^2]$$

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  $\eta_{ki}$  is to be calculated using  $E_{\text{sek,y}}$  according to 3.3.2.3.2(1).

3.3.7.5 Impediment of torsion through verification of sufficient torsional restraint

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

3.3.7.6 Verification of the compression chord as compression member

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

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

where  $E_{\text{Baustahl}} = 210000 \text{ N/mm}^2$  and  $E_{\text{sek,y}}$  according to 3.3.2.3.2(1).

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The reduction factor  $\kappa$  in condition (14) shall be determined according to clause 3.3.7.3.

3.3.7.7 Reduction factor  $\kappa_M$  for verifications of lateral torsional buckling

Formula (17) in element 311 may not be used here. Formula (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

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

where  $E_{\text{Baustahl}} = 210000 \text{ N/mm}^2$  and  $E_{\text{sek},y}$  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  $\kappa$  and  $\kappa_M$  in the conditions of the elements 312 to 320 are to be calculated according to the clauses 3.3.7.3 and 3.3.7.7.

In formula (23) in element 313,

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

$$\alpha \cdot (\bar{\lambda}_k - 0.13)$$

In condition (24)  $M_{\text{pl},d}$  shall be substituted by  $\rho_f \cdot M_{\text{pl},d}$ , and  $\Delta n / \rho_f$  is to be inserted instead of  $\Delta n$ . 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  $\rho_f$ , ensuing for the related slenderness  $\bar{\lambda}_k$  for which the reduction factor  $\kappa$  was determined. The values  $\rho_f$  indicated in the Tables of Annexes 14.1 to 14.4 are on the safe side.

In condition (26) in element 318, the buckling load factor  $\eta_{ki}$  with  $E_{\text{sek},y}$  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 verifications with the conditions (28) in element 321 and (29) in Element 322 shall not be furnished.

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

$$k_y = 1 \text{ and } k_z = 1.5$$

if the reduction factors  $\kappa$  and  $\kappa_M$  are calculated according to the clauses 3.3.7.3 and 3.3.7.7 and  $M_{\text{pl},z,d}$  is substituted by  $\rho_f^+ \cdot M_{\text{pl},z,d}$ . As a cautious approximation, the lower of the two values  $\rho_f$  may be inserted for  $\rho_f^+$  ensuing from the related slendernesses  $\bar{\lambda}_\kappa$  and  $\bar{\lambda}_M$  for which the reduction factors  $\kappa$  and  $\kappa_M$  were determined. The values  $\rho_f$  for lateral torsional

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buckling indicated in the Tables of Annexes 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, clause 7, may be basically used as simplified verifications according to clause 3.3.6.1.2 with due regard to the changes mentioned in clauses 3.3.7.10.2 to 3.3.7.10.9.

3.3.7.10.2 Application range

Regarding the note 1 in element 701, clause 3.3.5.3 shall be taken into account.

3.3.7.10.3 Verification procedure

Deviating from element 702, the verification 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  $\bar{\lambda}_{p\sigma}$ .

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

Effective width with bearing on one side:

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

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

$$b' = \frac{0.52}{\bar{\lambda}_p} \cdot b \quad \text{for} \quad \bar{\lambda}_p \geq 0.6875$$

where  $E_{sek,y}$  = 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 variables defined in DIN 18800-2:2008-11, element 712, these are:

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

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

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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 verification for regular axial compression

In element 716, in formula (91)

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

and the parameters  $\alpha$  in formula (92) are to be taken from Table 14 in clause 3.3.7.3.

### 3.3.7.10.7 Two-axial bending with and without normal force

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

### 3.3.7.10.8 Verification of the compression chord as compression member

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

### 3.3.7.10.9 General verification

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

## 3.3.8 Verifications according to DIN 18800-3:2008-11

### 3.3.8.1 General

DIN 18800-3:2008-11 may be applied for the verification of safety against buckling with regard to unstiffened plates, where the definitions in clauses 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  $E = 170000 \text{ N/mm}^2$  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  $\lambda_a$  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 Structural components without or with simplified verification

(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  $E_{\text{sek},y}$  behind the second 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  $\kappa_k$ , the value according to clause 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 $\kappa$

(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.

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(2) In element 603, formula (24), for the reduction factor for buckling  $\kappa_K$ , the value according to clause 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 Verifications according to DIN 18800-4:2008-11**

**3.3.9.1 Delimitation criteria**

In the condition indicating when no verification is necessary,  $E_{\text{sek},y}$  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 spherical shell 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 verification of safety against buckling for very long circular cylinders given in element 410, does not apply for stainless steels.

**3.3.9.2 Simplified verifications 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 clause 3.3.1.1(2)

for normal imperfection sensitive cases of shell buckling

$$\bar{\lambda}_s \geq 1.90$$

ensues, the verification 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 verification**

If for a case of shell buckling, the related slenderness ratio does not fulfill the condition to be applied according to clause 3.3.9.1 and 3.3.9.2, the verifications are in general to be furnished alternatively using one of the two linearized stress-strain relations according to clause 3.3.2.3.2. Furthermore, for the verification of safety against buckling, the definitions in clauses 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 formulas 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  $E = 170000 \text{ N/mm}^2$  for the general case.

**3.3.9.4 Verification for the cylindrical shell with compressive stress in axial direction**

The verification 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 clause 3.3.1.1(2), if the characteristic values of the real buckling stresses determined in this way are reduced by the factor  $\Psi$  dependent on the shell slenderness to the value

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

where for

$\Psi = 1$	for	$\bar{\lambda}_s \leq 0.40$
$\Psi = 1 - 0.735(\bar{\lambda}_s - 0.40)$	for	$0.40 \leq \bar{\lambda}_s \leq 0.74$
$\Psi = 0.75$	for	$0.74 \leq \bar{\lambda}_s \leq 1.00$

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$$\Psi = 0.75 + 0.658(\bar{\lambda}_s - 1) \quad \text{for} \quad 1.00 \leq \bar{\lambda}_s \leq 1.38$$

$$\Psi = 1 \quad \text{for} \quad 1.38 \leq \bar{\lambda}_s$$

applies.

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

3.3.10.1 General

(1) Structural 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 verification of the load-bearing capacity for structures made of welded hollow sections DIN 18808:1984-10 applies, including the appropriate 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 Verification of the wall thickness for unstiffened truss joints

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:

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

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 member dimensions for torsionally rigid stiff-jointed frameworks where

$$\vartheta = 90^\circ$$

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

3.3.10.4.2 Verification of the load-bearing capacity for weld joints

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

$$\alpha \leq 0.71 \quad \text{for steel grade 1 according to Annex 1, Table 1,}$$

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

**3.3.11 Verification of the fatigue strength of façade elements**

(1) For structural 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:

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

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

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

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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  $\alpha_k \cdot \sigma \leq 225 \text{ N/mm}^2$  under service load, a verification of fatigue resistance through tests is unnecessary for temperature related pulsating stress, where  $\alpha_k$  shall be inserted into the formula corresponding to the notch radius (for ex. for bolt threads according to DIN 13-1:1999-11  $\alpha_k = 4.0$ ). In this case, a verification 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 behaviour 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 structural components made of this steel shall also be classified for fire resistance.

**4 Provisions for execution of the structural components**

**4.1 General**

DIN 18800-7:2008-11 applies, unless otherwise specified 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 micro structure of the respective steel grade shall be taken into account according to Annex 1, Table 1.

Oxide films or annealing colours developed during thermal cutting processes shall be removed according to the requirements of corrosion protection (cf. clause 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 verification of the load-bearing capacity when they comprise more than 10% of the load-bearing cross sectional area.

If smaller softening zones shall be considered 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 clause 4.4.

Thermal treatments of austenitic and austenitic-ferritic steels during further processing are unallowable, except in single cases after hot forming, see clause 4.5.

**4.4 Cold forming**

During cold forming of components no cracks shall occur.

As a reference value for the minimum inside bend radii  $r$  regarding flat products up to a thickness of 3 mm, the following applies to annealed stainless steels:

- for austenitic grades  $r = 0$
- for austenitic-ferritic as well as for ferritic grades  $r = t$

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

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

where

$r$  = inside bend radii

$A_5$  = minimum elongation at fracture in % according to the technical delivery terms for annealed grades and for cold-worked grades 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 values of elongation at fracture  $A_5$  are lower in transverse direction, this shall be taken into account when bending in transverse direction by using these values in the formula above.

Lower radii  $r$  are permitted if for appropriate bending procedures the suitability (no cracks) is proven by an expertise of an approved body.

**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.

Hot forming is not permitted for structural components made of the steel grade 1.4016.

**4.6 Performance of welding work**

**4.6.1 General**

(1) Welding plants shall possess a manufacturer qualification corresponding to the fabrication, see clause 4.7. Welding shall be performed according to current welding procedure specification.

(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, arc stud welding with tip ignition, resistance spot welding, resistance flash welding, resistance butt welding and for friction welding component-specific production 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 15614-1:2012-06 shall be performed before starting production.

At this procedure test the proof strength  $R_{p0.2}$  shall be additionally verified for the respective application. The procedure test shall be performed with an approved body.

(2) 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.

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



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### **4.6.3 Resistance spot welding (21)**

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

### **4.6.4 Flash welding (24) and resistance butt 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 design resistance are defined.

### **4.6.5 Arc stud welding (78)**

#### **4.6.5.1 General**

DIN EN ISO 13918 applies unless other provisions are made in the following.

The studs shall be made of stainless steels according to DIN EN ISO 13918:2008-10.

Arc stud welding is only permitted on structural components made of:

- stainless steels with the material numbers 1.4062, 1.4162, 1.4301, 1.4307, 1.4401, 1.4404, 1.4541, 1.4571, 1.4362, 1.4462, 1.4439, 1.4662 as well as
- weldable carbon steel grades according to DIN EN 1993-1-1:2010-12 or according to DIN EN 1090-2:2011-10.

At least the standard quality requirements according to DIN EN ISO 3834-3:2006-03 shall be fulfilled.

The test of the arc stud welding shall be carried out according to DIN EN ISO 14555, clause 11.

#### **4.6.5.2 Additional rules for arc stud welding on the weldable carbon steel grades according to DIN EN 1993-1-1:2010-12 or according to DIN EN 1090-2:2011-10**

The following conditions shall be observed:

- stud diameter  $\leq 12$  mm,
- arc stud welding with shielding gas or ceramic ferrule,
- when using a ceramic ferrule, studs shall have an aluminum addition at the welding nozzle,
- only dry studs, ceramic ferrules and parts shall be processed. Ceramic ferrules which were already wet shall not be used any longer, also not after drying,
- the possibility that condensates occur caused by temperature changes shall be considered,
- the welding area shall be grinded metallic bright direct before welding,
- only power sources with constant power source characteristic shall be used,
- the equipment for arc stud welding including stud gun shall be calibrated according to DIN EN ISO 17662:2005-07,
- the original corrosion protection of the 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 design resistance are defined.

### **4.6.7 Laser welding (52)**

(1) At present, laser welding comes into consideration for the steel grades with the material numbers 1.4301, 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  $\leq 12$  mm. Black-white joints shall not be produced using this method.

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(2) Only strength class S235 shall be applied for the design 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 1.4301, 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 design resistance are defined. Only strength class S235 shall be applied for the design resistances.

**4.6.9 Flame-straightening**

(1) Flame straightening of structural 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 by using water or compressed air.

(5) The following conditions shall be observed:

Steel grade	Temperature of flame straightening*	Radiant heat color
Austenitic steels	650 °C - 750 °C	Brown-red to dark red
1.4003 1.4062 1.4162 1.4362 1.4462 1.4662	500 °C - 600 °C	Blue-grey until start dark red
* time at temperature max. 12 minutes for austenitic steels, max. 8 minutes for 1.4062, 1.4162, 1.4362 and 1.4462 as well as 4 minutes for 1.4003 and 1.4462		

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

(7) After straightening, annealing colors and oxide scales shall be completely removed through suitable measures. Flame straightening shall only be performed by trained staff under supervision of the welding coordinator.

(8) In case of cold-worked steels, softening due to flame straightening shall be taken into consideration for the verifications 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 condition for the heated zone.

Flame-straightening is not permitted for structural components made of the steel grade 1.4016.

**4.7 Requirements on the welding plants**

**4.7.1 General**

Welding work on structural components made of stainless steels may only be performed by welding plants disposing of a valid constructor's qualification for the used welding procedure and the steel grades to be welded.

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This qualification can be:

- a manufacturer's certificate according to DIN 18800-7:2008-11, extended for the scope of stainless steels of the class resulting from classification features in clause 4.7.2 as well as from the type of structural components and the welding process according to Table 9 to 12 of DIN 18800-7:2008-11,
- a welding certificate according to DIN EN 1090:2012-02, extended for the scope of stainless steels in connection with DIN EN 1090-2:2011-10 for the execution class (EXC) resulting from classification features in clause 4.7.3 as well as from the type of structural components and the welding process.

### **4.7.2 Manufacturer's certificate according to DIN 18800-7:2008-11**

(1) The strength class given in the structural documentation according to element 202 obtained from DIN 18800-7:2008-11 shall be used as classification feature.

(2) Welding on structural 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 in the strength class S235.

(3) Welding on structural 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.

(4) Welding on structural 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 only compression loading 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 up to and including strength class S275 (with only compression loading up to S355).

(5) Welding on structural components in class D:

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

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

### **4.7.3 Welding certificate according to DIN EN 1090-1:2012-02**

(1) The allocation of the structural components to the execution classes EXC1 to EXC4 according to Annex 2.4/2 of the *Musterliste der Technischen Baubestimmungen* ('List of Technical Constructions Regulations') applies unless other provisions are made in the following.

(2) Welding in execution class EXC1:

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

(3) Welding in execution class EXC2:

Mixed joints of stainless steels among each other considering the strength levels and black-white joints made of non-alloy carbon steels up to and including strength class S355 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 up to and including strength class S355

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(4) Welding in execution class EXC3 or EXC4:

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

(5) All execution classes are restricted to static loading of the structural components.

**4.7.4 Manufacturer's qualification for welding plants 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 clause 4.7.1.

**4.7.5 Prerequisite for welding stainless steels**

**4.7.5.1 Plant equipment**

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

**4.7.5.2 Applied welding processes**

For applying welding processes according to the clauses 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 clause 4.6.2 procedure tests shall exist, if this is necessary according to clause 4.6.2. For welding processes according to the clauses 4.6.3 to 4.6.8 welding procedure tests are always required.

**4.7.5.3 Welding coordinator**

**4.7.5.3.1 For manufacturer's certificate according to DIN 18800-7:2008-11**

The required level of technical knowledge regarding the welding coordinator ensues according to Table 14 of DIN 18800-7:2008-11 in dependence on the class of the required manufacturer's certificate. Accordingly, the welding coordinator 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

- specific knowledge for the respective field of application and the steel grades according to 4.7.2 (3) and (4) in the relative strength class for the classes B and C
- comprehensive knowledge for the class D

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

**4.7.5.3.2 For welding certificate according to DIN EN 1090-1:2012-02**

The required level of technical knowledge regarding the welding coordinator ensues according to Table 15 of DIN EN 1090-2:2011-10. Accordingly, the welding coordinator shall have additionally proven in a technical discussion the required knowledge concerning welding and working up of structural components and structures, including black-white joints in the face of the approved body.

**4.7.5.4 Welder**

For performing welding work, appropriately trained and approved welders according to DIN EN ISO 9606-1:2013-12 as well as trained and approved operators and set-up men according to DIN EN ISO 14732:2013-12 shall be deployed. Welders carrying out fillet welding shall have welded a fillet weld test specimen. The welding plant is obliged to necessarily make sure of work samples that the welder meets the quality requirements put on the structural part.

For the extension of validity of the welder's qualification test according to DIN EN ISO 9606-1:2013-12 and DIN EN ISO 14732:2013-12 the same rules apply as for the welders that are deployed in terms of DIN 18800-7:2008-11 or DIN EN 1090-2:2011-10.

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**5 Provisions for acceptance, service and maintenance**

**5.1 Acceptance**

For the acceptances bolts 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 ultimate limit state of the structural components, the steel surface of such structural 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.

Andreas Schult  
Head of section

*beglaubigt* ('confirmed'):  
Ulbrich

Table 1

No.	Steel grades <sup>1)</sup>		Micro-structure <sup>2)</sup>	Strength classes <sup>3)</sup> and product forms <sup>4)</sup>					Corrosion resistance class <sup>5) 6)</sup>
	Name	Steel 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	II / moderate
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	---	
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	X2CrNiN23-4	1.4362	FA	---	---	---	B, Ba, D, S, W	D, S	
13	X2CrNiN22-2	1.4062	FA	---	---	---	B, Ba, D, S, W	D, S	
14	X2CrMnNiN21-5-1	1.4162	FA	---	---	---	B, Ba, D, S, W	D, S	
15	X2CrNiMnMoCuN24-4-3-2	1.4662	FA	---	---	---	B, Ba, D, S, W	D, S	
16	X2CrNiMoN17-13-5	1.4439	A	---	B, Ba, D, H, S, W	---	---	---	IV / high
17	X2CrNiMoN22-5-3	1.4462	FA	---	---	---	B, Ba, D, P, S, W	D, S	
18	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	
19	X2CrNiMnMoNbN25-18-5-4	1.4565	A	---	---	---	B, Ba, D, S	---	V / very high
20	X1NiCrMoCuN25-20-7	1.4529	A	---	B, D, S, W	B, D, H, P, S	D, P, S	D, S	
21	X1CrNiMoCuN20-18-7	1.4547	A	---	B, Ba	B, Ba	---	---	

<sup>1)</sup> according to DIN EN 10088-1:2005-09

<sup>2)</sup> A = Austenite; F = Ferrite; FA = Ferrite – Austenite (Duplex)

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

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

<sup>5)</sup> applies to metallic bright surfaces only

<sup>6)</sup> required corrosion resistance class see Annex 1.1, Table 1.1

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

Products, fasteners and structural components made of stainless steels

Annex 1

Exposure	Exposure class		Criteria und examples	Corrosion resistance class				
				I	II	III	IV	V
humidity, yearly average value U of humidity	SF0	dry to seldom moist	U < 95 %	X				
	SF1	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 < 10 µg/m <sup>3</sup>	rural, urban, M > 10 km, S > 0.1 km	X				
	SC1	medium 10 – 90 µg/m <sup>3</sup>	industrial zone, 1 km < M ≤ 10 km, 0.01 km < S ≤ 0.1 km		X			
	SC2	high 90 – 250 µg/m <sup>3</sup>	maritime zone 0.25 km < M ≤ 1 km S ≤ 0.01 km			X <sup>1)</sup>		
	SC3	very high	splash water zone M ≤ 0.25 km				X <sup>2)</sup>	
exposure to SO <sub>2</sub> <sup>3)</sup>	SR0	low	rural, urban	X				
	SR1	medium	industry			X <sup>1)</sup>		
	SR2	high	road tunnel					X <sup>2)</sup>
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			
location of structural components	SL0	indoors	indoors, heated and not heated	X				
	SL1	outdoors, exposed to rain	exposed structures		X			
	SL2	outdoors, accessible but protected from weather	roofed structures		X			
	SL3	outdoors, non-accessible <sup>4)</sup> , ambient air has access	accumulation of pollutants by air pollution, cleaning not possible				X	

The exposure leading to the highest Corrosion Resistance Class (CRC) shall be taken into account.  
No higher requirements result from the coincidence of different 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 components.
- 2) If **accessible** structures are cleaned regularly corrosion will be much lower and the CRC may be reduced by one class.
- 3) The determination of exposure shall be in accordance with ISO 9225 on the basis of the average gas concentration in the air.
- 4) Structures are classified as **non-accessible** if an inspection of their condition is extremely difficult and a necessary rehabilitation is very expensive.

Products, fasteners and structural components made of stainless steels

Annex 1.1

**Table 1.1:**  
Choice of steel grade under atmospheric exposure

**Table 2**

Steel grades				Corrosion resistance class <sup>1)</sup>	Marking of bolts with head on the basis of DIN EN ISO 3506-1			Marking of threaded bars, threaded dowels, nuts and washers on the basis of DIN EN ISO 3506-1 + -2		
No.	Name	Steel number	Group		Strength class			Strength class		
					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	X2CrNiN23-4	1.4362	<sup>2)</sup>		---	≤ M 24	≤ M 20	---	≤ M 64	≤ M 20
13	X2CrNiN22-2	1.4062	<sup>2)</sup>		---	≤ M 24	≤ M 20	---	≤ M 39	≤ M 20
14	X2CrMnNiN21-5-1	1.4162	<sup>2)</sup>		---	≤ M 24	≤ M 20	---	≤ M 39	≤ M 20
15	X2CrNiMnMoCuN24-4-3-2	1.4662	<sup>2)</sup>		---	≤ M 24	≤ M 20	---	≤ M 39	≤ M 20
16	X2CrNiMoN17-13-5	1.4439	<sup>2)</sup>	IV / high	≤ M 20	---	---	≤ M 64	---	---
17	X2CrNiMoN22-5-3	1.4462	<sup>2)</sup>		---	≤ M 24	≤ M 20	---	≤ M 64	≤ M 20
18	X1NiCrMoCu25-20-5	1.4539	<sup>2)</sup>		≤ M 39	≤ M 24	≤ M 20	≤ M 64	≤ M 45	≤ M 20
19	X2CrNiMnMoNbN25-18-5-4	1.4565	<sup>2)</sup>	V / very high	---	≤ M 24	≤ M 20	---	≤ M 64	≤ M 30
20	X1NiCrMoCuN25-20-7	1.4529	<sup>2)</sup>		≤ 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.

Products, fasteners and structural components made of stainless steels

**Table 2**

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

Annex 2



**Table 3**

Strength class	Steel grades		R <sub>p0,2</sub> N/mm <sup>2</sup>	R <sub>m</sub> N/mm <sup>2</sup>	A <sub>5</sub> <sup>1)</sup> %	
	No.acc. Table 1	Steel number			Strip, plate flat products	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
	18	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
	18	1.4539			-	20
	20	1.4529			30	30
21	1.4547	30	-			
S 460	1	1.4003	460	600	-	10
	3	1.4301			20	12
	4	1.4307			20	12
	5	1.4567			650	12
	6	1.4541			650	12
	7	1.4318			650	12
	8	1.4401			650	12
	9	1.4404			650	12
	10	1.4578			650	12
	11	1.4571			650	12
	18	1.4539			650	12
20	1.4529	650	22			
S 690	9	1.4404	690	800	-	10
	11	1.4571			-	10
	12	1.4362			-	10
	13	1.4062			-	10
	14	1.4162			-	10
	15	1.4662			-	10
	17	1.4462			-	10
	18	1.4539			-	10
	19	1.4565			-	10
	20	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

Products, fasteners and structural components made of stainless steels

**Table 3:**  
Mechanical properties after cold-working (minimum values) for steel grades for structural components and initial products for fasteners

Annex 3

**Table 4**

Parent material	Rod electrode acc. to DIN EN ISO 3581	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	NiCr22Mo9Nb <sup>1)</sup>	20 25 5 Cu N L NiCr22Mo9Nb <sup>2)</sup>	-
1.4439	18 16 5 N L	18 16 5 N L	18 16 5 N L
1.4362, 1.4462 1.4662	22 9 3 N L	22 9 3 N L	22 9 3 N L
1.4062, 1.4162	22 9 3 N L 23 7 N L	22 9 3 N L 23 7 N L	22 9 3 N L 23 7 N L
1.4529	NiCr23Mo16 <sup>1)</sup> NiCr22Mo9Nb <sup>1)</sup>	NiCr23Mo16Cu2 <sup>2)</sup> NiCr22Mo9Nb <sup>2)</sup>	-
1.4547	NiCr22Mo9Nb <sup>1)</sup>	NiCr22Mo9Nb <sup>2)</sup>	-

- 1) according to DIN EN ISO 14172:2009-03  
2) according to DIN EN ISO 18274:2011-04

Products, fasteners and structural components made of stainless steels

**Table 4:**  
Allocation of filler material for stainless steels

Annex 4

**Table 5** Allocation of filler material to mixed joints between austenitic steels and the ferritic steel grade with steel number 1.4003

1	2	3	4
Rod electrodes acc. to DIN EN ISO 3581	Wire electrodes, wire and rods acc. to DIN EN ISO 14343	Filled wire electrodes acc. to DIN EN ISO 17633	Yield strength $f_{y,k}$ <sup>1)</sup> N/mm <sup>2</sup>
23 12 L	23 12 L	23 12 L	320
23 12 2 L	23 12 2 L	23 12 2 L	350
20 10 3	20 10 3	20 10 3	400
18 8 Mn	18 8 Mn	18 8 Mn	350
NiCr20Mn3Nb <sup>2)</sup>	NiCr20Mn3Nb <sup>3)</sup>	-	355
NiCr16Fe12NbMo <sup>2)</sup>	NiCr20Mo15 <sup>3)</sup>	-	355

- 1) Shall be used as characteristic value for calculation of load bearing capacity of welded joints according to section 3.3.5.8  
2) according to DIN EN ISO 14172:2009-03  
3) according to DIN EN ISO 18274:2011-04

**Table 6** Allocation of filler material to mixed joints between stainless steels with the steel numbers 1.4003, 1.4301, 1.4307, 1.4401, 1.4541, 1.4571, 1.4404, 1.4318, 1.4539, 1.4547, 1.4439, 1.4529, 1.4565 and carbon steels / fine grain steels

1	2	3	4
Rod electrodes acc. to DIN EN ISO 3581	Wire electrodes, wire and rods acc. to DIN EN ISO 14343	Filled wire electrodes acc. to DIN EN ISO 17633	Yield strength $f_{y,k}$ <sup>1)</sup> N/mm <sup>2</sup>
18 8 Mn	18 8 Mn	18 8 Mn	350
20 10 3	20 10 3	20 10 3	400
23 12 L	23 12 L	23 12 L	320
23 12 2 L	23 12 2 L	23 12 2 L	350
NiCr20Mn3Nb <sup>2)</sup>	NiCr20Mn3Nb <sup>3)</sup>	-	355
NiCr16Fe12NbMo <sup>2)</sup>	NiCr20Mo15 <sup>3)</sup>	-	355
NiCr23Mo16 <sup>2)</sup>	NiCr23Mo16Cu2 <sup>3)</sup>	-	355
NiCr22Mo9Nb <sup>2)</sup>	NiCr22Mo9Nb <sup>3)</sup>	-	355
NiCr19Mo15 <sup>2)</sup>	NiCr20Mo15 <sup>3)</sup>	-	355

- 1) Shall be used as characteristic value for calculation of load bearing capacity of welded joints according to section 3.3.5.8  
2) according to DIN EN ISO 14172:2009-03  
3) according to DIN EN ISO 18274:2011-04

**Table 7** Allocation of filler material to mixed joints between austenitic-ferritic steels with the steel numbers 1.4062, 1.4162, 1.4362, 1.4462 or 1.4662 and austenitic steels as well as carbon steels / fine grain steels

1	2	3	4
Rod electrodes acc. to DIN EN ISO 3581	Wire electrodes, wire and rods acc. to DIN EN ISO 14343	Filled wire electrodes acc. to DIN EN ISO 17633	Yield strength $f_{y,k}$ <sup>1)</sup> N/mm <sup>2</sup>
22 9 3 N L	22 9 3 N L	22 9 3 N L	450
NiCr20Mn3Nb <sup>2)</sup>	NiCr20Mn3Nb <sup>3)</sup>	-	355
NiCr16Fe12NbMo <sup>2)</sup>	NiCr20Mo15 <sup>3)</sup>	-	355

- 1) Shall be used as characteristic value for calculation of load bearing capacity of welded joints according to section 3.3.5.8  
2) according to DIN EN ISO 14172:2009-03  
3) according to DIN EN ISO 18274:2011-04

Products, fasteners and structural components made of stainless steels

**Table 5, Table 6 and Table 7:**  
Allocation of filler material to mixed joints between the different steel grades

Annex 5

**Table 8**

Maximum thickness of products for structural components and for sections and hollow sections in cold-worked state made of the products

Strength class	Plate, strip and hollow sections			Rods and wire, extruded and cold-formed sections		
	No. acc. to Table 1	Steel number	max t <sup>1)</sup> mm	No. acc. to Table 1	Steel number	max d <sup>1)</sup> mm
S 275	3	1.4301	6 <sup>2)</sup>	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	6 <sup>2)</sup>	6	1.4541	60
	11	1.4571	6	8	1.4401	80
	18	1.4539	6	9	1.4404	80
				10	1.4578	30
				11	1.4571	80
				18	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
	20	1.4529	6	9	1.4404	60
	21	1.4547	6	10	1.4578	30
				11	1.4571	40
				18	1.4539	80
			20	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
				18	1.4539	50
			20	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
				12	1.4362	60
				13	1.4062	40
				14	1.4162	40
				15	1.4662	40
			17	1.4462	60	
			18	1.4539	50	
			20	1.4529	50	

- 1) Larger 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 certificate.
- 2) max t ≤ 12.5 mm if verified accordingly

Products, fasteners and structural components made of stainless steels

**Table 8:** Maximum thickness of products for structural parts

Annex 6

**Table 9**

Plate, strip and hollow sections			Rods and wire, extruded and cold-formed sections		
No. acc. to Table 1	Steel number	max t <sup>1)</sup> mm	No. acc. to Table 1	Steel number	max d <sup>1)</sup> mm
1	1.4003	12	1	1.4003	25
3	1.4301	6 <sup>2)</sup>	3	1.4301	25 <sup>2)</sup>
8	1.4401		8	1.4401	
4	1.4307	30	4	1.4307	45
6	1.4541		6	1.4541	
7	1.4318		7	1.4318	
9	1.4404		9	1.4404	
11	1.4571		11	1.4571	
16	1.4439	12	16	1.4439	25
18	1.4539		18	1.4539	
19	1.4565		19	1.4565	
20	1.4529		20	1.4529	
21	1.4547				
12	1.4362	30	12	1.4362	45
13	1.4062	30	13	1.4062	40
14	1.4162	30	14	1.4162	40
15	1.4662	30	15	1.4662	40
17	1.4462	30	17	1.4462	45

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

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

**Table 10**

Structural components in swimming pool atmospheres <sup>2)</sup>	Steel grades
with regular cleaning of the structural components	choice of corrosion resistance class according to Table 1.1
without regular cleaning <sup>1)</sup> of the structural components	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)) 2<sup>nd</sup> 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 or leakages and leading there to high concentrations.

Products, fasteners and structural components made of stainless steels

**Table 9:** Maximum thickness for welded structural components  
**Table 10:** Steel grades for swimming pools

Annex 7

Table 11

1	2	3		4		5	6		7	8	9	
		Strength class	Steel number	Yield strength <sup>5)</sup>				Tension resistance <sup>5)</sup>	E-Modulus, modulus of shear (G)		Coefficient of thermal expansion	Density
				structural components <sup>1)</sup>		welded joints <sup>2)</sup>			for structural analysis			
				cold rolled strip <sup>3)</sup>	other	cold rolled strip <sup>3)</sup>	other		general <sup>4)</sup> except by constraint stresses and verification of stability acc. to section 3.3.2.3	constraint stresses		
f <sub>y,k</sub>		f <sub>y,k</sub>		f <sub>u,k</sub>	E	G						
N/mm <sup>2</sup>		N/mm <sup>2</sup>		N/mm <sup>2</sup>	N/mm <sup>2</sup>	N/mm <sup>2</sup>	10 <sup>-6</sup> x K <sup>-1</sup>	kg/dm <sup>3</sup>				
S 235	1.4567	--	175	--	--	450	170 000	200 000	16	7.9		
	1.4578									8.0		
	1.4301					7.9						
	1.4307	220	190	220	190	500						
	1.4541											
	1.4401											
	1.4404	240	200	240	200							
	1.4571											
	1.4539	240	220	240	220							
	1.4003	240	240	240	240	450						
1.4016	--	240	--	--	400							
S 275	1.4301					550	170 000	200 000	16	7.9		
	1.4307	275		275	275							
	1.4541											
	1.4567	--		--	--							
	1.4578											
	1.4401											
	1.4404	275	275	275	275							
	1.4571											
	1.4539											
	1.4003	--		--	--							
	1.4439	290		290	275							
	1.4529	300	300	300	300							
1.4547	275	--	275	--	600							
S 355	1.4003	--	355	--	320	600	170 000	200 000	16	7.9		
	1.4318	350	330	350	300							
	1.4301											
	1.4307	355		355	355							
	1.4541											
	1.4567	--		--	--							
	1.4578		355									
	1.4401											
	1.4404	355		355	355							
	1.4571											
	1.4539	--		--	320							
	1.4529				355							
	1.4529	355		355	355							
	1.4547		--		--							

continuation  
Annex 8.2

Table 11: Characteristic values for structural components including welded joints

Products, fasteners and structural components made of stainless steels

Annex 8.1

Table 11 (continuation)

1	2	3		4		5	6		7	8	9				
		Yield strength <sup>5)</sup>					Tension resistance <sup>5)</sup>	E-Modulus, modulus of shear (G)				Coefficient of thermal expansion	Density		
		structural components <sup>1)</sup>		welded joints <sup>2)</sup>				for structural analysis							
		cold rolled strip <sup>3)</sup>	other	cold rolled strip <sup>3)</sup>	other			general <sup>4)</sup>						constraint stresses	
								except by constraint stresses and verification of stability acc. to section 3.3.2.3							
f <sub>y,k</sub>		f <sub>y,k</sub>		f <sub>u,k</sub>	E	E									
N/mm <sup>2</sup>		N/mm <sup>2</sup>		N/mm <sup>2</sup>	G	G									
					N/mm <sup>2</sup>	N/mm <sup>2</sup>	10 <sup>-6</sup> x K <sup>-1</sup>	kg/dm <sup>3</sup>							
S 460	1.4565	460	420	350	350	600	170 000	200 000	16	8.0					
	1.4003	--		--	320				10	7.7					
	1.4301	460	460	355	355				16	7.9					
	1.4307														
	1.4318		--	--											
	1.4541			355											
	1.4567	--	460	--	--				13	8.0					
	1.4578														
	1.4401	460		355	355										
	1.4404														
	1.4539	--		--	320										
	1.4571	460		355	355										
	1.4529	--		--	420				8.1						
	1.4362	450	400	400	400				600	7.8					
	1.4462	480	460	450	450										
	1.4062	530	450	450	450										
1.4162	530	450	450	450											
1.4662	550	480	480	480											
				700											
S 690	1.4301	--	690	--	355	800	170 000	200 000	16	7.9					
	1.4307				320					8.0					
	1.4539				420					8.1					
	1.4529														
	1.4401										355				8.0
	1.4404														
	1.4571														
	1.4362										400	65 400	76 900	13	7.8
	1.4462										450				
	1.4062										400				
	1.4162										450				
	1.4662										450				
											450				

- 1) For verifications 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 achieved. The maximum values for calculation of mixed joints are listed in Table 5 to 7. This only apply to the welding processes 111, 121, 131, 135, 136 und 141.
- 3) according to DIN EN 10088-4
- 4) For verifications of stability according to sections 3.3.7 to 3.3.9 section 3.3.2.3 shall be considered.
- 5) The characteristic values are valid up to the maximum thicknesses given in Table 8, Annex 6 and Table 9, Annex 7 and shall be guaranteed by the 0.2%-proof-strength R<sub>p0.2</sub> (f<sub>y,k</sub>) and the tensile strength R<sub>m</sub> (f<sub>u,k</sub>) in the material inspection certificate 3.1.

Table 11 : Characteristic values for structural parts including welded joints

Products, fasteners and structural components made of stainless steels

Annex 8.2

**Table 12**

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

**Table 13**

	1	2	3	4	5
	Welds acc. to DIN 18800-1, Table 19	Weld quality	Kind of loading	Austenitic and autenitic-ferritic steel grades	Steel 1.4003
1	Line 1-4	all weld qualities	compression	1.0	1.0
2		weld quality proved	tension, shear		
3		weld quality not proved		0.95	0.80
4	Line 5-15	all weld qualities	compression, tension, shear		

Products, fasteners and structural components made of stainless steels

**Table 12:** Characteristic values for fastening elements

**Table 13:**  $\alpha_w$ -values for limit weld stresses

Annex 9



**Table 14**

Buckling stress curves	a	b	c	d
$f_{y,k}$ in N/mm <sup>2</sup>				
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

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**Table 14:** Parameter  $\alpha$  for calculation of the reduction factor  $\kappa$   
(substitute for Table 4 of DIN 18800-2)

Annex 10

**Table 15**

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

$\eta = \sqrt{\frac{E_{sek,y}}{E}}$  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),  
 $\sigma_{pI}$  and  $\tau_{pI}$  shall be calculated with  $\sigma_e$  according to section 3.3.8.2.

Products, fasteners and structural components made of stainless steels

**Table 15:** Reducing factor  $\kappa$  (= related bearing buckling stress)  
at single effect of  $\sigma_x$ ,  $\sigma_y$  or  $\tau$

Annex 11

**Table 16**

Line	Range of validity
1	$d \leq 150\text{mm}$ $h \leq 340\text{mm}$ $b \leq 340\text{mm}$
2	$0.5 \leq h/b \leq 2.0$
3	$1.5\text{mm} \leq t \leq 15\text{mm}$
4	$d/t \leq 35$ $b/t \leq 35$

**Table 17**

Line	Range of validity	
	with	without
	stiffening plate	
1	$b \leq 340\text{mm}$	$b \leq 240\text{mm}$
	$h \leq 340\text{mm}$	$h \leq 240\text{mm}$
2	$0.33 \leq h/b \leq 3.5$	
3	$2.5\text{mm} \leq t \leq 15\text{mm}$	
4	$b/t \leq 26 ; h/t \leq 26$	

Products, fasteners and structural components made of stainless steels

Annex 12

**Table 16:** Limits and conditions for member dimensions in lattice girder made of hollow sections  
**Table 17:** Limits and conditions for member dimensions in bending rigid stiff-jointed framework with  $\vartheta = 90^\circ$  and with mitre joint

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 202 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  $\kappa_1$  is indicated in the upper left corner in brackets apply according to the formulas 7 in Element 204. For shell slendernesses  $\bar{\lambda}_s \geq 2.00$ , formula 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  $\Psi$  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 formulas 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  $\kappa_2$  is indicated in the upper left corner in brackets. .

a) For shell slendernesses  $1.35 \leq \bar{\lambda}_s < 1.58$  formula 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  $1.58 \leq \bar{\lambda}_s < 2.37$  formula 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  $\sigma_{Si}$ . Therefore  $f_{y,k}^* \geq 190\text{N/mm}^2$  shall be observed.

c) For shell slendernesses  $2.37 \leq \bar{\lambda}_s$  formula 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 apply.

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 formulas 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 ( $\kappa_1$ ) susceptible to imperfection.

Products, fasteners and structural components made of stainless steels	Annex 13
Characteristic values of the real buckling stresses $\sigma_{S,R,k}$ according to DIN 18800-4, Element 203	

$\lambda_s$ ( $\kappa_1$ )	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

$\lambda_s$ ( $\kappa_2$ )	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	38	37	37	36	36	35
1.3	35	34	34	34	33	33	33	32	32	31

Products, fasteners and structural components made of stainless steels

Characteristic values of the real buckling stresses  $\sigma_{S,R,k}$  [N/mm<sup>2</sup>]  
according to DIN 18800-4, Element 203, formula 4 for  $f_{y,k} = 190$  N/mm<sup>2</sup>

Annex 13.1

$\lambda_s$ ( $\kappa_1$ )	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

$\lambda_s$ ( $\kappa_2$ )	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

Products, fasteners and structural components made of stainless steels

Characteristic values of the real buckling stresses  $\sigma_{S,R,k}$  [N/mm<sup>2</sup>]  
according to DIN 18800-4, Element 203, formula 4 for  $f_{y,k} = 200$  N/mm<sup>2</sup>

Annex 13.2

$\lambda_s$ ( $\kappa_1$ )	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

$\lambda_s$ ( $\kappa_2$ )	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

Products, fasteners and structural components made of stainless steels

Characteristic values of the real buckling stresses  $\sigma_{S,R,k}$  [N/mm<sup>2</sup>]  
according to DIN 18800-4, Element 203, formula 4 for  $f_{y,k} = 220$  N/mm<sup>2</sup>

Annex 13.3

$\lambda_s$ ( $\kappa_1$ )	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

$\lambda_s$ ( $\kappa_2$ )	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

Products, fasteners and structural components made of stainless steels

Characteristic values of the real buckling stresses  $\sigma_{S,R,k}$  [N/mm<sup>2</sup>]  
according to DIN 18800-4, Element 203, formula 4 for  $f_{y,k} = 240$  N/mm<sup>2</sup>

Annex 13.4



$\lambda_s$ ( $\kappa_1$ )	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

$\lambda_s$ ( $\kappa_2$ )	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

Products, fasteners and structural components made of stainless steels

Characteristic values of the real buckling stresses  $\sigma_{S,R,k}$  [N/mm<sup>2</sup>]  
according to DIN 18800-4, Element 203, formula 4 for  $f_{y,k} = 275$  N/mm<sup>2</sup>

Annex 13.5

$\lambda_s$ ( $\kappa_1$ )	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

$\lambda_s$ ( $\kappa_2$ )	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

Products, fasteners and structural components made of stainless steels

Characteristic values of the real buckling stresses  $\sigma_{S,R,k}$  [N/mm<sup>2</sup>]  
according to DIN 18800-4, Element 203, formula 4 for  $f_{y,k} = 290$  N/mm<sup>2</sup>

Annex 13.6

$\lambda_s$ ( $\kappa_1$ )	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

$\lambda_s$ ( $\kappa_2$ )	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

Products, fasteners and structural components made of stainless steels

Characteristic values of the real buckling stresses  $\sigma_{S,R,k}$  [N/mm<sup>2</sup>]  
according to DIN 18800-4, Element 203, formula 4 for  $f_{y,k} = 300$  N/mm<sup>2</sup>

Annex 13.7

$\lambda_s$ ( $\kappa_1$ )	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

$\lambda_s$ ( $\kappa_2$ )	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

Products, fasteners and structural components made of stainless steels

Characteristic values of the real buckling stresses  $\sigma_{S,R,k}$  [N/mm<sup>2</sup>]  
according to DIN 18800-4, Element 203, formula 4 for  $f_{y,k} = 330$  N/mm<sup>2</sup>

Annex 13.8

$\lambda_s$ ( $\kappa_1$ )	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

$\lambda_s$ ( $\kappa_2$ )	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

Products, fasteners and structural components made of stainless steels

Characteristic values of the real buckling stresses  $\sigma_{s,R,k}$  [N/mm<sup>2</sup>]  
according to DIN 18800-4, Element 203, formula 4 for  $f_{y,k} = 355$  N/mm<sup>2</sup>

Annex 13.9

$\lambda_s$ ( $\kappa_1$ )	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	83	82	81	80	79	78	77	77	76
1.9	76	75	74	73	73	72	71	70	70	69

$\lambda_s$ ( $\kappa_2$ )	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

Products, fasteners and structural components made of stainless steels

Characteristic values of the real buckling stresses  $\sigma_{S,R,k}$  [N/mm<sup>2</sup>]  
according to DIN 18800-4, Element 203, formula 4 for  $f_{y,k} = 420$  N/mm<sup>2</sup>

Annex 13.10

$\lambda_s$ ( $\kappa_1$ )	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	106	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

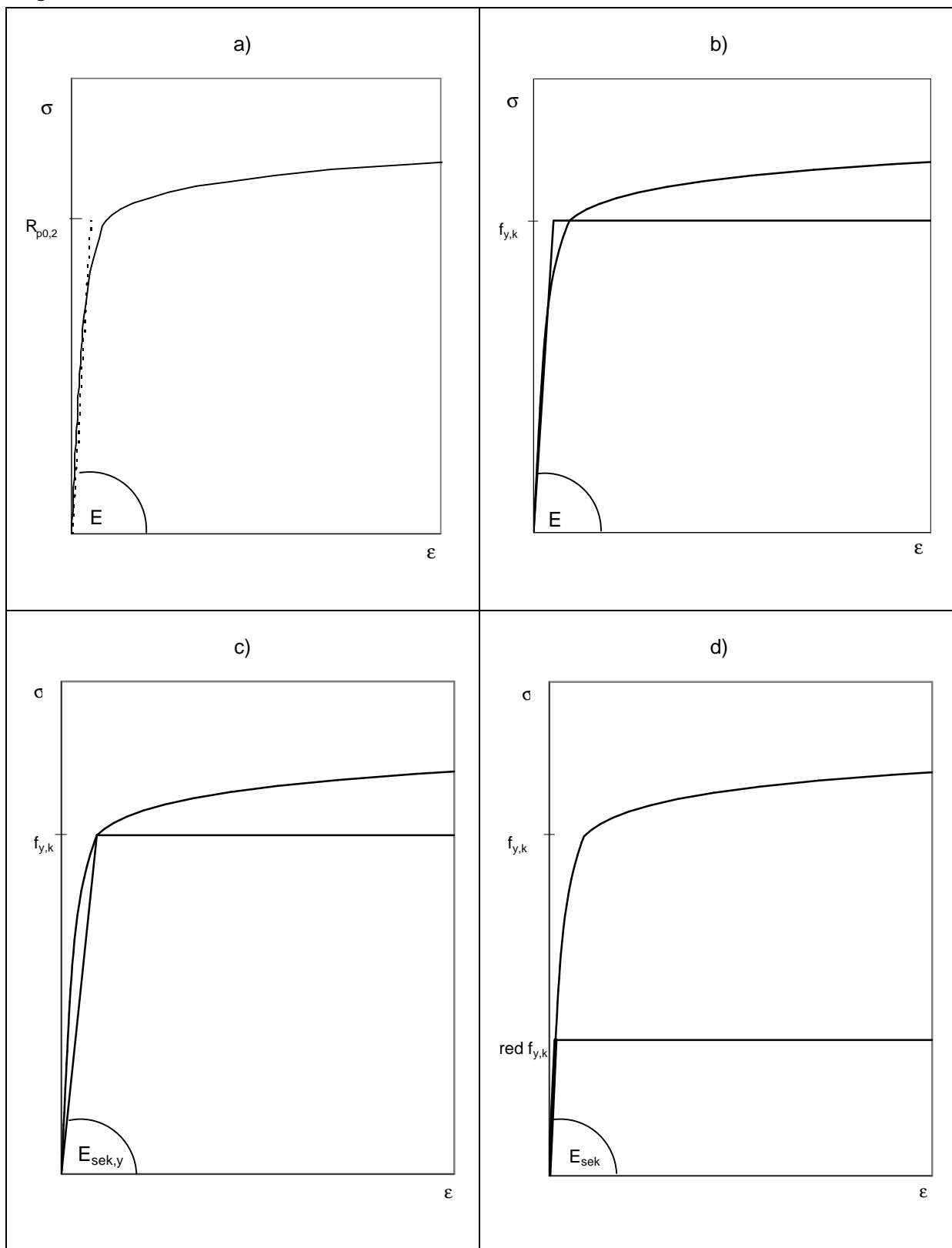
$\lambda_s$ ( $\kappa_2$ )	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.1	460	460	460	460	460	460	460	460	460	460
0.2	454	448	443	437	431	426	420	414	409	403
0.3	397	392	386	380	375	369	363	357	351	346
0.4	340	335	329	324	319	314	309	304	300	295
0.5	290	286	282	277	273	269	265	261	257	253
0.6	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

Products, fasteners and structural components made of stainless steels

Characteristic values of the real buckling stresses  $\sigma_{S,R,k}$  [N/mm<sup>2</sup>]  
according to DIN 18800-4, Element 203, formula 4 for  $f_{y,k} = 460$  N/mm<sup>2</sup>

Annex 13.11

Figure 1



Products, fasteners and structural components made of stainless steels

**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



	buckling stress curve a									
$\bar{\lambda}_k$	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.4	1.00	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

Products, fasteners and structural components made of stainless steels

Yield strength reduction factor  $\rho_f$  for flexural bending for  $f_{y,k} = 175 \text{ N/mm}^2$   
and buckling stress curve a

Annex 14.1

	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

Products, fasteners and structural components made of stainless steels

Yield strength reduction factor  $\rho_f$  for flexural bending for  $f_{y,k} = 175 \text{ N/mm}^2$   
and buckling stress curve b

Annex 14.2

	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

Products, fasteners and structural components made of stainless steels

Yield strength reduction factor  $\rho_f$  for flexural bending for  $f_{y,k} = 175 \text{ N/mm}^2$   
and buckling stress curve c

Annex 14.3

	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

Products, fasteners and structural components made of stainless steels

Yield strength reduction factor  $\rho_f$  for flexural bending for  $f_{y,k} = 175 \text{ N/mm}^2$   
and buckling stress curve d

Annex 14.4

$f_{y,k} = 190$	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	1.00
0.4	1.00	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	0.84	0.83
0.8	0.79	0.78	0.77	0.77	0.76	0.76	0.76	0.75
1.0	0.71	0.70	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	0.65
1.4	0.58	0.59	0.60	0.60	0.61	0.61	0.61	0.62
1.6	0.54	0.55	0.57	0.57	0.58	0.58	0.58	0.59
1.8	0.50	0.52	0.54	0.54	0.55	0.56	0.56	0.57
2.0	0.47	0.49	0.51	0.52	0.53	0.54	0.54	0.55
2.2	0.44	0.46	0.49	0.49	0.51	0.52	0.52	0.53
2.4	0.41	0.44	0.47	0.47	0.49	0.50	0.50	0.52
2.6	(0.39)	0.42	0.45	0.46	0.48	0.48	0.48	0.50
2.8	(0.37)	(0.40)	0.43	0.44	0.46	0.47	0.47	0.49
3.0	(0.36)	(0.39)	0.42	0.43	0.45	0.46	0.46	0.48
3.2	(0.34)	(0.38)	0.41	0.42	0.44	0.45	0.45	0.47
3.4	(0.33)	(0.36)	(0.40)	0.41	0.43	0.44	0.44	0.46
3.6	(0.32)	(0.35)	(0.39)	(0.39)	0.42	0.43	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	1.00
0.6	1.00	1.00	1.00	0.99	0.98	0.97	0.97	0.96
0.8	0.91	0.90	0.89	0.88	0.88	0.87	0.87	0.87
1.0	0.80	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	0.75	0.76
1.4	0.66	0.67	0.69	0.69	0.70	0.71	0.71	0.72
1.6	0.61	0.63	0.65	0.65	0.67	0.67	0.67	0.69
1.8	0.56	0.59	0.61	0.62	0.64	0.64	0.64	0.66
2.0	0.53	0.56	0.58	0.59	0.61	0.62	0.62	0.64
2.2	0.49	0.53	0.56	0.57	0.59	0.60	0.60	0.62
2.4	0.47	0.50	0.54	0.54	0.57	0.58	0.58	0.60
2.6	0.44	0.48	0.51	0.53	0.55	0.56	0.56	0.58
2.8	0.42	0.46	0.50	0.51	0.53	0.54	0.54	0.57
3.0	(0.40)	0.44	0.48	0.49	0.52	0.53	0.53	0.55
3.2	(0.39)	0.43	0.47	0.48	0.50	0.52	0.52	0.54
3.4	(0.37)	0.41	0.45	0.46	0.49	0.50	0.50	0.53
3.6	(0.36)	(0.40)	0.44	0.45	0.48	0.49	0.49	0.52

The yield strength reduction factor  $\rho_f = \text{red } f_{y,k}/f_{y,k}$  basic for the calculation of the reduction factor  $\kappa_M$  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  $E = 170,000 \text{ N/mm}^2$  according to DIN 18800-2:2008-11 without further modifications.

Products, fasteners and structural components made of stainless steels

Yield strength reduction factor  $\rho_f$  for torsional-flexural bending

Annex 15

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 <sup>1)</sup>		Wire		Sections <sup>2)</sup>	Hollow sections (pipes)	Fastening elements and dowels
Name	Postcode/Location Internet		cold rolled	hot rolled	rolled	drawn (bright steel)	rolled	drawn			
Aperam Stainless Services & Solutions Germany GmbH	D-40699 Erkrath www.aperam.com	X	X	X							
Böllinghaus Steel GmbH	D-40723 Hilden www.boellinghaus.de				X	X			X		
Deutsche Edelstahlwerke GmbH	D-58452 Witten 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
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		
Outokumpu EMEA GmbH	D-47807 Krefeld www.outokumpu.com	X	X	X	X	X	X	X			
Ugitech GmbH	D-71272 Renningen www.ugitech.com				X	X	X	X	X		
Valbruna Edel Inox GmbH	D-41542 Dormagen www.valbruna.de				X	X	X	X			
Walzwerke Einsal GmbH	D-58769 Nachrodt www.einsal.com				X	X		X	X		

1) forged long products as well

2) hot rolled and also from hot rolled plates cut profiles, edged/bended profiles, laser beam welded profiles as well as hot extruded special profiles

Manufacturers of products according to Annex 1, Table 1

(Informative)

Products, fasteners and structural components made of stainless steels

Annex 16