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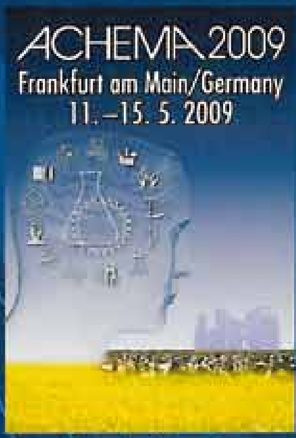




Schwerpunkt 5/2009
Industrieller Anlagenbau und Kraftwerkstechnik



# Current status of the DIN EN 13480-3

## Metallic industrial piping – Designs and calculation

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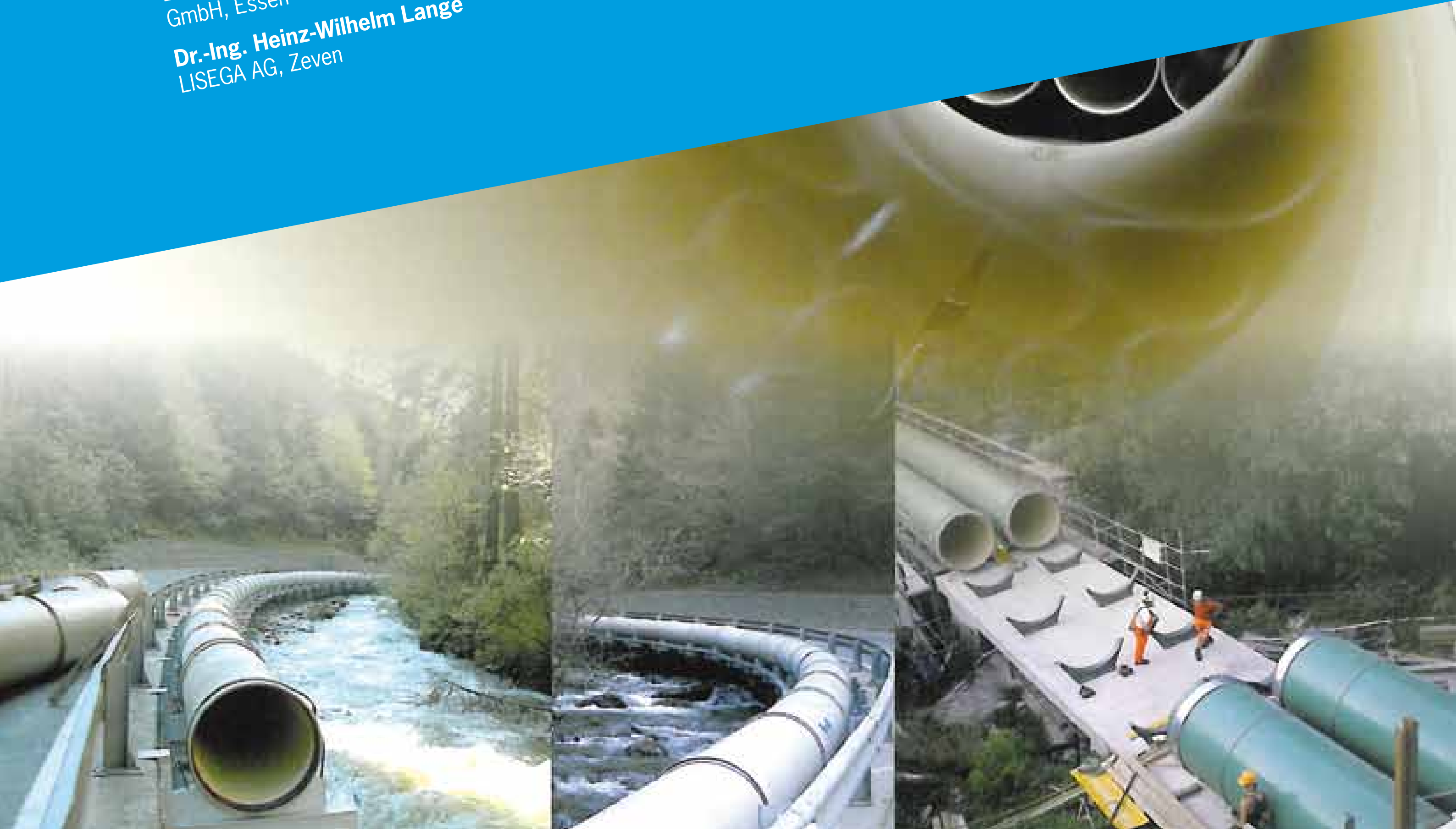


# Current status of the DIN EN 13480-3

## Metallic industrial piping – Designs and calculation

Dr. Jochen Weber, Dr. Heinz-Wilhelm Lange

*This article reports on the current status of the EN 13480-3. Information was also provided on this subject at the 24th FDBR Conference of Piping Technology in March 2009 in Magdeburg, Germany. The code was published in the year 2002 and was at first applied with some hesitation, but is now widely followed. To create a common European code "Metallic industrial piping systems – Design and calculation", which has grown out of a variety of national guidelines, was an impressive feat by all those involved, which will not be depreciated or placed in question here. However, as is to be expected with such a new and complex set of rules, some weak points and errors became evident in its implementation. The FDBR working group "Festigkeitsberechnung / Technische Regelwerke" (Strength Calculation and Technical Codes) has identified these errors and elaborated corrective suggestions.*
*On the occasion of the 22nd Plenary Session of the CEN/TC267 in November 2008 it was agreed that this year, 2009, an updated working version of the norm will first be created. This forms the basis of the planned publication of a revised edition of the EN 13480-3 in the first quarter of 2010. Unfortunately, at the moment very few European countries are participating in the revision of the code.*

*Dieser Beitrag berichtet über den aktuellen Stand der EN 13480-3, über dieses Thema wurde auch im Rahmen der 24. FDBR-Fachtagung Rohrleitungstechnik (Rohrleitungstechnische Tagung) im März 2009 in Magdeburg berichtet. Die Norm wurde im Jahre 2002 veröffentlicht und zunächst nur zögerlich, mittlerweile aber doch auf breiter Front, angewendet. Eine gemeinsame europäische Norm „Metallische industrielle Rohrleitungen – Konstruktion und Berechnung" zu erstellen, die aus verschiedenen nationalen Regelwerken zusammengewachsen ist, war eine große Leistung aller daran Beteiligten, die hier auch nicht geschmälert oder gar in Frage gestellt werden soll. Trotzdem, wie bei einem solch komplexen, neuen Regelwerk nicht anders zu erwarten, zeigten sich bei der Anwendung einige Schwachstellen und Fehler. Der FDBR-Arbeitskreis „Festigkeitsberechnung / Technische Regelwerke" hat diese Fehler gesammelt und Korrekturvorschläge erarbeitet. Anlässlich der 22. Plenarsitzung des CEN/TC267 im November 2008 wurde vereinbart, dass in diesem Jahr 2009 zunächst eine aktualisierte Arbeitsversion der Norm erstellt wird. Diese bildet die Grundlage dafür, dass im 1. Quartal 2010 eine überarbeitete Ausgabe der EN 13480-3 veröffentlicht werden kann. Leider beteiligen sich derzeit nur sehr wenige europäische Länder an der Überarbeitung der Norm.*

### Origination, history and current status

The technical committee CEN/TC267, whose office is run by AFNOR in Paris, is responsible for the elaboration of the EN 13480 – part 1 to 8. AFNOR also runs the offices of WG3, responsible for EN 13480-3, and WG8, the maintenance group.

The final draft version of the EN 13480-3 was adopted by the working group responsible, CEN/TC 267/WGC (now renamed WG3) in October 2001. Four to five German experts were permanently active in WGC. This paper finally went through the obligatory editorial revision by an editing committee whose aim was to examine compliance with the formal guidelines of the CEN concerning European standards and if necessary to make corrections. In this phase of the revision, however, a large number of printing errors, particularly with regard to equations and illustrations, were unfortunately made.

The first issue in German language appeared as DIN EN 13480-3 in August 2002. Since it was produced under some pressure of time it contains a number of language inconsistencies which additionally complicate its application. Immediately after publication of the standard a help desk was set up at TC267 (WG8) with the aim of answering any queries within 30 days.

A committee in Germany which dealt very rapidly with the deficiencies of EN 13480-3 is the FDBR working group "Rohrleitungen" (Piping). Its achievement is the "legendary" bulletin FDBR-MB 7, which contains initial suggestions for correction. All the corrections and suggestions from German sources were collected and processed in the FDBR working group "Festigkeitsberechnung und Technische Regelwerke" (Strength Calculation and Technical Codes). This working group has in the meantime become the official German mirror committee to CEN/TC267, as the joint working group FDBR "Festigkeitsberechnung und Technische Regelwerke" / DIN NA082-00-17 AA "Rohrleitungen" (Strength Calculation and Technical Codes / DIN NA082-00-17 AA Piping). The processed requests for modifications were forwarded to CEN/TC267 and on the whole accepted.

Supplements and technical changes in the standard can be made by way of amendments. These supplements to the standard are then usually voted on following a unique acceptance procedure (UAP) by the member states. The UAP is a single stage acceptance procedure; the amendment prepared will be brought forward for written approval throughout Europe within a limited period of time. The appendices O and P are originated in this manner;

Appendix Q is currently under debate. The appendices will be dealt with later.

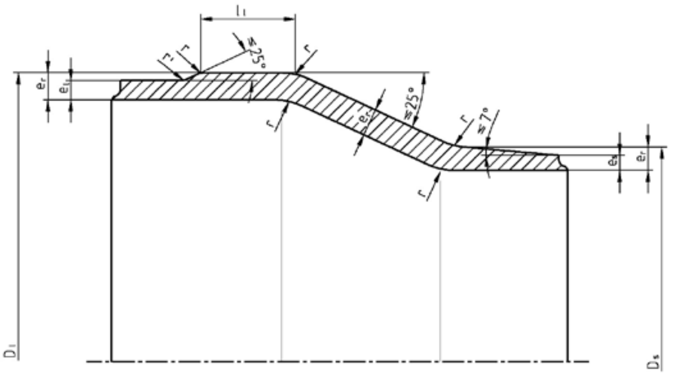
All amendments so far made are available free of charge from the publishers Beuth.

On the occasion of the 21st Plenary Session of the CEN/TC267 in November 2007 it was decided to revise all parts of the EN 13480. The target date for the new issue of the EN 13480-3 is the first quarter of 2010.

In the following the essential corrections and supplements to various sections of the standard, as well as the appendices, are described. The treatment of the section "Pipe Supports" then follows, with the relevant appendices.

**Bild 1:** Geschmiedete Spezialreduzierstücke, alternative Bauform (Vorschlag) [Bild 6.4.10-2]

**Fig. 1:** Special forged reducers, alternative solution (proposal) [Fig. 6.4.10-2]



## Section 6.4 Reducers

Section 6.4, Reducers, was taken over from the British Standard BS 5500 (PD 5500 today) [1]. The authors of EN 13480-3 have endeavoured to adopt additional equations and explanations as against BS 5500 in this section. For example, equations allowing the determination of the permissible pressure PS of a reducer were added – that is practically the test as to whether the design has been carried out correctly. However, these supplementary passages are in part more confusing than helpful.

Two fundamental problems arise with the dimensioning of a reducer:

- The procedure required for the dimensioning does not correspond to the sequence in which the equations are noted. First the cylindrical components of the reducer (large and small diameter) must be dimensioned according to the equations in Section 6.1. After that the characteristic diameter $D_K$ is determined, for which some equations from Sections 6.4.5 and 6.4.6 or 6.4.7 have to be evaluated before the wall thickness of the cone can be calculated according to Section 6.4.4.
- The results are in part determined iteratively, by making assumptions of wall thickness which are then confirmed or corrected by evaluating equations. This leads amongst other things to calculation programs producing different results, depending on the grade of accuracy of the iteration performed – this again has led to discussions with notified bodies.

A further problem arises if only minor differences in nominal diameters are to be connected by means of a reducer. In these cases the required length $2l_2$ between two cylinder/cone connections cannot always be maintained. Therefore notified bodies under certain circumstances may demand a different proof, which ends up with FEM analyses being carried out.

From the results of such FEM analyses the suggestion was made to dispense under certain circumstances with the length $2l_2$ between cylinder/cone connections without additional proof.

The suggestion accepted in the meantime by CEN/TC267 intends additionally inserting the following text into Section 6.4.5:

*The length of the cone can be reduced to less than $2l_2$ if both of the following conditions are fulfilled.*

*The wall thickness $e_2$, calculated in accordance with 6.4.6 or 6.4.7, is existent along the whole length of the cone.*

*The junction at the small end of the cone is sufficiently dimensioned according to 6.4.8.*

FEM analyses performed indicate that a shortening of the cone to a length smaller than the required dimension $2l_2$ is permissible under the boundary conditions mentioned. In this way the dimensioning of reductions of minor diameter differences according to EN 13480-3 is possible.

In section Section 6.4.10, "Special forged reducers", the equation lacking till now (6.4.10-5) is added, as well as an explanation:

$$e_r = \max(e_{cyl}; e_j) \qquad (6.4.10\text{-}5)$$

with $e_{cyl}$ according to Section 6.1 and $e_j$ according to Eq. (6.4.7-4)

In Fig. 6.4.10-1 a number of minor corrections were made. An alternative component design is included as Fig. 6.4.10-2 – **Fig. 1.**

## Section 8.4 Isolated openings

The calculation of oblique nozzles should proceed analogously to TRD 301 [9] or TRD 303 and thereby also correspond to the calculation rules set out in EN 12952-3. This proposal by the German delegation was accepted as early as 1996 in the WGC. However, the corresponding figures did not actually appear in the drafts until spring 2001. In the final stage of work on the standard, in the Editing Committee, the wrong figures were inserted again and an additional area $A_{Pb\phi}$ defined **Fig. 2**, compare Fig. 8.3-1 in EN 12952-3 with Fig. 8.4.3-3 in EN 13480-3 and **Fig. 3**, compare Fig. 8.3-2 in EN 12952-3 with Fig. 8.4.3-4 in EN 13480-3. After the 22nd CEN/TC267 plenary session in November 2008, the justified hope exists that this error can now be finally corrected without applying to CEN for a work item, as the TC267 has accepted the fact that only an editorial error and not an error in content was made.

## Section 12.3 Flexibility analysis

The fundamental equations for the performance of the flexibility analysis were adopted from the FDBR guideline [10] "Design of Power Piping". The safety factor against minimum tensile strength was thereby reduced from 4.0 to 3.0, which at moderate calculation temperatures leads to an increase in the stress limit $f_h$ over the previous $S_h$ and also thereby to an increase in $f_a$ as against $S_a$. In this way the limit for secondary stresses was raised, while at the same time, however, the limit for the primary stresses resulting from the limitation to $f_h$ instead of the earlier $S_m$ was lowered.

The Germans made the suggestion that a new symbol $f_f$ – design stress for flexibility analysis – should be introduced. This proposal, already accepted in the TC267, aims at restoring the old limitation for the primary stresses.

## Problem

In EN 13480-3, $f_h$ is applied, instead of the value $S_m$ of the FDBR guideline [10].

In some cases the definition of $f_h$ in Section 12 leads to more restrictive stress limits than the source of this Section, the FDBR guideline [10]

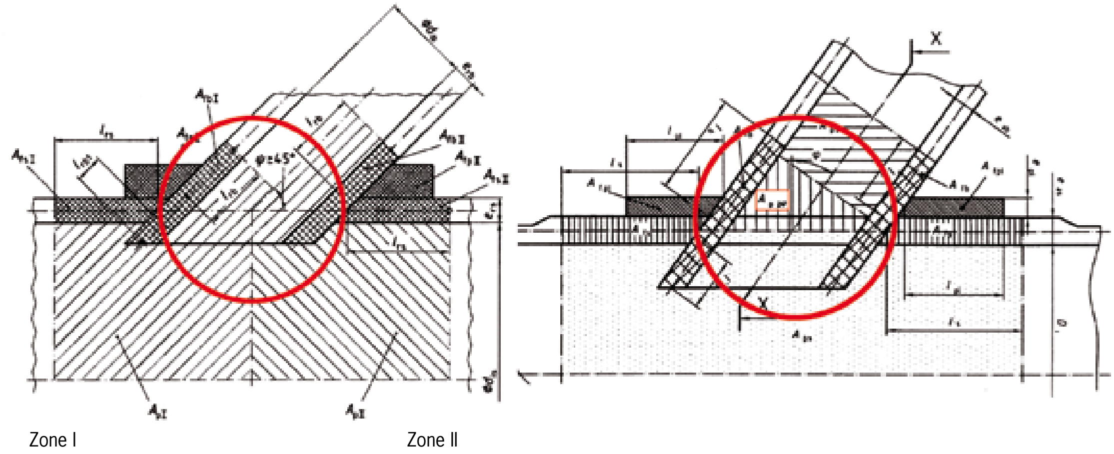



**Bild 2:** Schräger Abzweig, axial geneigt in EN 13480-3 (links) und EN 12952-3 (rechts)

**Fig. 2:** Oblique branch, axial inclination in EN 13480-3 (left side) and EN 12952-3 (right side)

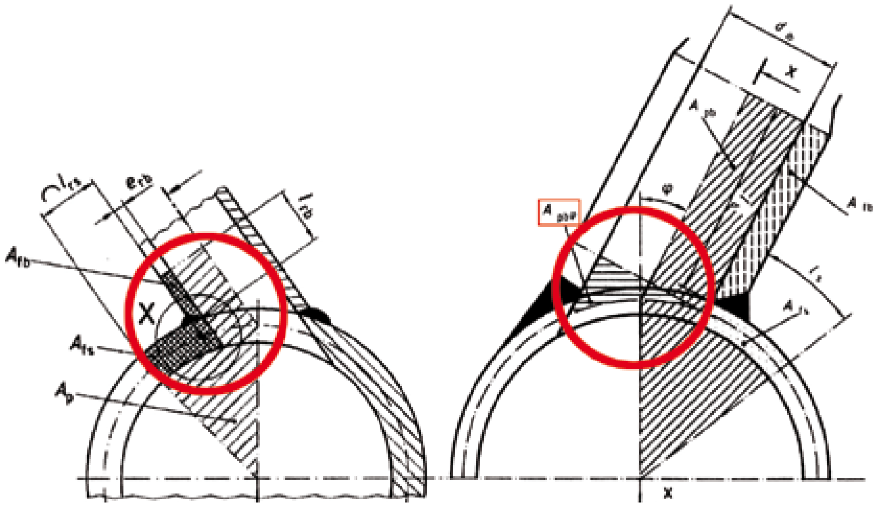


**Bild 3:** Schräger Abzweig, tangential geneigt in EN 13480-3 (links) und EN 12952-3 (rechts)

**Fig. 3:** Oblique branch, tangential inclination in EN 13480-3 (left side) and EN 12952-3 (right side)

"Design of Power Piping". This applies especially to non-austenitic steels at moderate operating temperatures. A typical example is the HP feed water piping made of 15NiCuMoNb5-6-4 (WB36), see the following example.

- FDBR guideline:

$$S_m = \min.\left(\frac{R_m}{2.4};\ \frac{R_{p0.2t}}{1.5};\ \frac{S_{R200.000t}}{1.25}\right)$$

- EN 13480-3:

$$f_h = \min.\left(\frac{R_m}{3.0};\ \frac{R_{eH}}{1.5};\ \frac{R_{p0.2t}}{1.5};\ \frac{S_{RTt}}{SF_{CR}}\right)^*$$

* resulting from $f_h$ = min. $(f_c;f;f_{cr})$ (12.1.3-3)

**Tab. 1:** Spannungsbegrenzungen für Werkstoff 15NiCuMoNb5-6-4 bei TS = 300 °C nach EN 13480-3, FDBR-Richtlinie und Änderungsvorschlag zu EN 13480-3

**Table 1:** Stress boundaries for material 15NiCuMoNb5-6-4 at TS = 300 °C acc. to EN 13480-3, FDBR-Guideline and proposed change to EN 13480-3

| | EN 13480-3 | FDBR guideline | Proposal |
|---|---|---|---|
| Primary stresses Eq. (12.3.2-1) | $f_h$ = 203 MPa | $S_m$ = 254 MPa | $f_f$ = 254 MPa |
| Primary stresses sustained + occasional Eq. (12.3.3-1) | $k \cdot f_h = k \cdot 203$ MPa | $k \cdot S_m = k \cdot 254$ MPa | $k \cdot f_f = k \cdot 254$ MPa |
| Secondary stresses Eq. (12.3.4-1) | $f_a$ = 276 MPa | $S_a$ = 207 MPa | $f_a$ = 276 MPa |
| Primary and secondary stresses Eq. (12.3.4-2) | $f_h + f_a$ = 479 MPa | $S_m$ + Sa = 461 MPa | $f_f$ + fa = 530 MPa |

### Proposal

A new symbol $f_f$ should be introduced.

$f_f$ - *Design stress for flexibility analyses (flexibility calculations) in N/mm² (MPa) with*

*$f_f$ = min (f; $f_{CR}$).*

*$f_f$ is applied in the equations (12.3.2-1, (12.3.3-1) and (12.3.3-2) instead of $f_h$.*

### Justification

In accordance with the pressure equipment directive (PED) the stress limit $R_m$/2,4 applies for the dimensioning of components based on membrane stresses. The sum of membrane and bending stresses in the flexibility analysis should not be limited to a lower value.

The example in **Table 1** shows the consequences of this alteration for piping made of the material 15NiCuMoNb5-6-4 at TS = 300 °C. The permissible stresses for the evaluation of sustained loads and the sum of sustained and occasional or exceptional loads are thereby raised again to the level of the FDBR guideline [10]. The permissible stresses for the evaluation of alternating secondary loads are in this case increased compared to the FDBR guideline, which can be ascribed to the above-mentioned reduction of the safety factor.

## Amendment 1: 2005-11, Annex O (normative)

## Alternative procedure for the testing of branch connections

In Section 8, Openings and branch connections, a reference to the normative Annex O was adopted, which contains an alternative calculation procedure for openings, opening reinforcements and branches. The procedure described in Annex O is based on limit load design and shakedown;

unfortunately, no mention of sources (literature) was made. The following advantages as against the standard procedure in section 8 were distinguished:

- Especially suitable for large openings
- Consideration of bending and torsion moments is possible in addition to consideration of the internal pressure.

The second statement must be put into perspective. Bending and torsion moments are currently considered according to Section 12, so here it is simply a question of a different evaluation procedure.

The procedure must not be applied to branches used in the creep range. In Annex O it is additionally pointed out that this calculation is applicable for loads of predominately non-cyclic nature. However, indications are lacking of necessary reinforcing lengths or distances between openings.

Annex O has been agreed to by way of UAP.

The German mirror committee DIN NA082-00-17 AA – represented for the most part by FDBR working group "Strength Calculation and Technical Codes" – has attempted to obstruct Annex O, or at least have a more thorough professional examination made, as misgivings exist concerning the application of the procedure to openings in thin-walled shells.

Germany was the only European country to reject Annex O in this form. However, as the UAP had already been initiated at this juncture, only the obvious errors in equations and diagrams could be corrected.

The equations (O.3.1-1) and (O.3.1-2) for determining the permissible pressure in straight piping should not be applied. The pressures thereby calculated lead to Tresca equivalent stresses in the piping which amount to approximately 1.15 $R_{p0,2t}$, that is, to pressures at which plastification / yielding sets in.

**Tab. 2:** Vergleich EN 13480-3 Abschnitt 8, Anhang O und ASME B31.1 – Abmessungen und Berechnungsdrücke

**Table 2:** Comparison EN 13480-3 clause 8, Annex O and ASME B31.1 – dimensions and calculation pressures

| Example No. | $D_m$ in mm | $d_m$ in mm | $e_s$ in mm | $e_b$ in mm | $p_c$ in MPa |
|---|---|---|---|---|---|
| 1 | 200 | 80 | 20 | 20 | 16.78 |
| 2 | 400 | 200 | 20 | 10 | 4.950 |
| 3 | 400 | 200 | 10 | 5 | 2.057 |
| 4 | 400 | 200 | 10 | 15 | 3.603 |
| 5 | 2000 | 300 | 20 | 4 | 1.059 |
| 6 | 2000 | 1000 | 20 | 10 | 0.616 |
| 7 | 2000 | 2000 | 20 | 20 | 0.533 |

However, the equation (O.3.2-3), for example, supplies the same wall thickness required for c = 1.0 (pipe without opening) in accordance with section 6.1.

**Tables 2 and 3** show a comparison between the calculation procedures on the basis of several examples. Specified mean diameters of run pipe and branch were assumed, as well as the specified wall thickness of the branch. The required wall thickness of the run pipe was calculated. The permissible stress is f = 90 MPa in all examples.

The symbols $e_s$ and $e_b$ stand for determined wall thickness. If measured wall thicknesses are meant by this, the results in **Table 3** are correct. If however calculated wall thicknesses are meant, an iterative procedure is required, since the weakening coefficients change dependently on the wall thicknesses.

The examples show that, for thin-walled branches, in part considerably smaller wall thicknesses are determined than with the standard procedure according to Section 8. As a comparison the calculation according to ASME B31.1[3] was also included. The deviations between EN 13480-3 and ASME B31.1 are substantiated by using either the Kellogg-method (EN 13480-3) or the area replacement method (ASME B31.1) and are well known.

**Conclusion:** the misgivings that non-conservative results ensue from openings in thin-walled shells have been confirmed at least in part, but the results do not deviate as widely as according to ASME B31.1. It was not examined here what differences appear in the evaluation of bending and torsion moments in comparison to Section 12.

## Amendment 2: 2007-02, Annex P (informative)

## Bolted flange connections – Application of EN 1591

The first issue of EN 13480-3 treats the calculation of flange connections in a very negligent fashion in section 6.6 "Bolted flange connections". Only three possibilities are shown there to evaluate the strength behaviour of a flange connection.

**Tab. 3:** Vergleich EN 13480-3 Abschnitt 8, Anhang O und ASME B31.1 – Ergebnisse

**Table 3:** Comparison EN 13480-3 clause 8, Annex O and ASME B31.1 – results

| Example No. | $d_m$ / $D_m$ | $D_m$ / $e_s$ | $e_b$ / $e_s$ | $e_s$ according to Section 8 in mm | $e_s$ according to Annex O in mm | Deviation Annex O | $e_s$ according to ASME B31.1 in mm | Deviation ASME B31.1 |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.4 | 10 | 1.0 | 20.0 | 20.86 | +4.3% | 19.5 | -2.5% |
| 2 | 0.5 | 20 | 0.5 | 20.0 | 18.02 | -9.9% | 21.6 | +8.0% |
| 3 | 0.5 | 40 | 0.5 | 10.0 | 8.95 | -10.5% | 8.9 | -11.0% |
| 4 | 0.5 | 40 | 1.5 | 10.0 | 9.96 | -0.2% | 12.6 | +26.0% |
| 5 | 0.15 | 100 | 0,2 | 20.0 | 14.85 | -25.7% | 23.6 | +18.0% |
| 6 | 0.5 | 100 | 0.5 | 20.0 | 19.22 | -3.9% | 13.4 | -33.0% |
| 7 | 1.0 | 100 | 1.0 | 20.0 | 17.89 | -10.6% | 11.7 *) | -41.5% |

*) Wall thickness $e_b$ also has to be 11.7 mm.

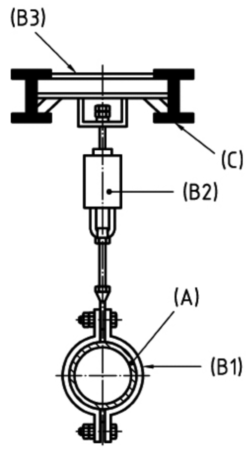



**Bild 4:** Verbindung von Federhänger und Zwischentragwerkskonstruktion [Bild 13.1.4-2]

**Fig. 4:** Spring support to steel Intermediate structures [Figure 13.14.4-2]

- Selection according P-T ratings, i.e. application of EN 1092
- Application of the Taylor-Forge Method, see also EN 13480-3 Annex D (normative)
- Application of EN 1591 – if special demands concerning leak tightness are to be considered

It is well known that the calculation of DIN flange connections according to the Taylor-Forge Method does not usually work. With the application of EN 1591, the stress analyst was left out in the rain for a long time, because the EN 1591-1 may describe the procedure for calculation, but the EN 1591-2, which is to supply the required characteristic gasket properties, was on hand for some time, but only as an incomplete draft. Just as a reminder – the characteristic gasket properties used till now for calculations according to AD 2000 – bulletin B7 and B8 [11] or DIN V 2505 [12] are insufficient for calculation according to EN 1591.

It was attempted with the informative Annex P to close this gap and to better establish the application of EN 1591 in piping construction. In addition, Annex P contains a range of characteristic gasket properties with which the application of EN 1591-1 is at all made possible.

The formulation in Section 6.6 rendered more rigorous by the integration of Annex P is unfortunately worded, in the authors' opinion: "If a standard flange is specified in a European standard, and no further requirement is given, the flange shall be selected by means of the P/T rating." In this way it is implicitly forbidden to reflect both on an implementation going beyond the P-T ratings as well as on the strength and tightness behaviour of the flange connection, which is also dependent in the end on bolts and gasket. It would be better to say at this juncture: "*…the flange may be selected – insofar as applicable – according to the pressure-temperature rating.*"

Annex P was also agreed to by way of UAP.

Annex P contains:

- Instructions on the application of EN 1591
- Recommended gasket materials for industrial piping systems
- Characteristic gasket properties, mainly for soft material gaskets as well as grooved gaskets with graphite covering.

## Amendment 3: 2009-1, various alterations

Amendment 3 contains corrections to Section 2, to the sub-Sections 8.4.3, 13.1.4, 13.3.1, C.1.1, D.4.1 E.2.1.1, as well as to Annexes H and N and the literature index, and was accepted per UAP in April 2008.

## Amendment 4: UAP, started up in 2009-4, Annex Q (informative)

### Simplified pipe stress analysis

Till now, EN 13480-3 contains no rules for simplified stress analysis (routing guideline), as is normal in other rules and standards. The draft of the standard contained at least a table of allowable width between supports but was not included in the first edition in 2002. Annex Q originated from a German proposal. This annex contains a calculation method for determining the permissible widths between supports, as well as a flexibility check.

The calculation methods correspond to the procedure as defined in TRR 100 and in AD 2000 – bulletin HP 100 R [11]. The tables of allowable widths between support were revised; the values given in Annex Q differ slightly from those in AD 2000 – bulletin HP 100 R.

## Section 13: Supports

One of the biggest "construction sites" in EN 13480-3 in Section 13, with the corresponding Annexes. In the changes, differentiation is made between

- [ ge ] = general
- [ te ] = technical
- [ ed ] = editorial
- [ tr ] = translation

If the number of changes in Section 13 is compared with the other parts of the standard, above-average changes are necessary. Large parts are translation errors or unhappily phrased translations that change the sense of the text. In the German version the title is "Abstützungen" – the literal translation of the English title "Supports". Normally, all pipe-holding components, i.e. supports and hangers, are described as "supports" in English language usage – the more meaningful German translation is "Rohrhalterungen" *(lit.: pipe holders).*

A few examples should demonstrate how inappropriate terms and translations can confuse the reader.

In the legend of (**Fig. 4**) "Spring support to steel intermediate structures" [Figure 13.1.4.-2] the following explanations are to be found:

- (A) pipe
- (B1) pipe clamp
- (B2) pipe support
- (B3)secondaryorintermediatesteelwork***to be built in by the support manufacturer***
- (C) steelwork

Even a glance at the original English version of the standard does not help us much further:

- (B3) secondary or intermediate steelwork ***to be constructed by the support manufacturer***

A number of unfortunate circumstances coincide here: the German translation is certainly not what the originators of the standard intended. A literal fulfillment of the standard, often generally demanded in specifications, leads in cases of doubt to discussions concerning the different shipments, considering that the intermediate steelwork could under certain circumstances lie within the field of building law.

A further example of confusing formulations in Section 13.1.3 "Supplementary terms" is the definition

*"13.1.3.1. Verankerung: starre Vorrichtung, die an der Stützstelle die gesamte relative Verdrehung und Verschiebung der Rohrleitung bei Auslegungstemperatur und -belastung verhindert und selbst Bewegungen unterworfen sein kann."*

("13.1.3.1 anchorage: rigid device, used to prevent all relative pipe rotation and displacement at the point of application under the design conditions of temperature and loading – and which may itself be subject to imposed displacement.")

A look at the English version shows what type of pipe support is actually meant:

"13.1.3.1. anchor: rigid device, which may itself be subject to imposed displacement, used to prevent all relative pipe rotation and displacement at the point of application, under the design conditions of temperature and loading."

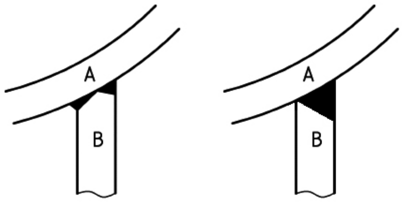



**Bild 5:** An das Rohr angeschweißte Abstützung [Bild 13.1.5-1] (akt. Norm / Änderungsvorschlag)

**Fig. 5:** Support welded to the piping [Figure 13.1.5-1] (act. Standard / modification proposal)

By "anchor", fixed points are normally meant. Reading the text, one is inclined to think of the famous comment "… but it does move!". During the discussion in working group 3 of TC 267 the formulation "… und selbst Bewegungen unterworfen sein kann" ("… and may itself be subject to displacement") was explained. Connection points on vessels or similar are thereby meant; in some calculation programs these are defined in a similar way to anchors. In the next edition anchors, as generally accepted, are so defined:

*"13.1.3.1 Festpunkt: starre Vorrichtung, die an der Stützstelle die gesamte relative Verdrehung und Verschiebung der Rohrleitung bei Auslegungstemperatur und -belastung verhindert."*

("13.1.3.1 Fixed point: rigid device, used to prevent all relative pipe rotation and displacement at the point of application, under the design conditions of temperature and loading.")

The list of corrections to the German translation is fairly copious. As a final example of translation errors, the definition of rigid struts should be mentioned here:

*"13.1.3.9 Gelenkstrebe: Einrichtung, die die Rohrleitung in einer Ebene hält; gilt üblicherweise für dynamische Belastung."*

("13.1.3.9 Rigid strut: device to restrain the piping in a plane, applies generally to dynamic loading.")

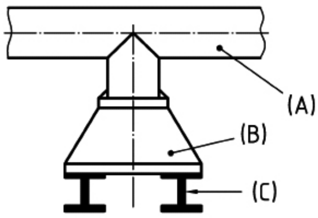
The English original describes the function of rigid struts more clearly, for rigid struts act only in one direction.

*"13.1.3.9 Rigid strut: device to restrain the piping in a single direction, generally during dynamic loading."*

Here too, in the next version of the standard a common definition is used:

*"13.1.3.9 Gelenkstrebe: Einrichtung, die die Rohrleitung in einer Richtung hält und üblicherweise für dynamische Belastung eingesetzt wird."*

("13.1.3.9 Rigid strut: device to restrain the piping in a single direction, in many cases used for dynamic loading.")



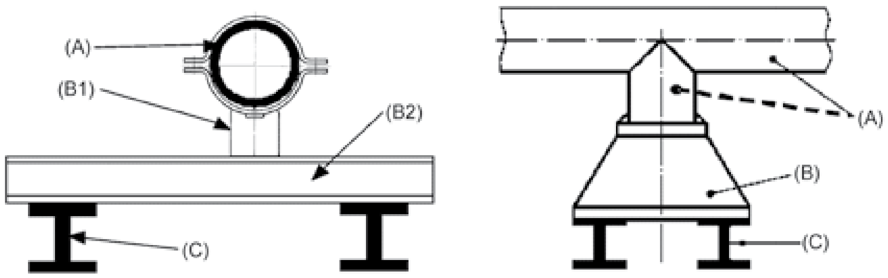

Key:
(A) Pipe
(B) Pipe Support
(C) Steel structure

**Bild 6:** Verbindung zu Stahltragwerk [Bild 13.1.4-1] (akt. Norm)

**Fig. 6:** Connections to steel structures [Figure 13.1.4.-1] (act. Standard)

Additionally, in the definition part of Section 13 some details not generally included are shown in the illustrations. For example (**Fig. 5**) "Support welded to the piping [Figure 13.1.5-1] shows two weld seams."

In pipe supports with NB 900 it is possible up to a certain length to weld the pipe support to the pipe, as shown in the diagram on the left. In general, however, it will be a matter of a fillet weld or a full penetration weld.




Pipe support made of standard components

Customised pipe support

Key:
(A) pipe
(B) pipe support (e.g. clamp base)
(C) structure
(B) pipe support
(B2) pipe support (e.g. intermediate steel)

**Bild 7:** Verbindung zu Stahltragwerk [Bild 13.1.4-1] (Änderungsvorschlag)
**Fig. 7:** Connections to steel structures [Figure 13.1.4.-1] (modification proposal)

It is a similar case with (**Fig. 6**) "Connections to steel structures" [Figure 13.1.4-1] in which an anchor (fixed point), is shown as a special design. Most users of the standard will, however, use standardized pipe supports as far as possible. Such a figure placed exclusively in the definition part leads to confusion amongst less experienced pipe system designers. The figure was discussed intensively in working group 3. The French delegation insisted on keeping this figure in the definition, as it is also presented in this form in CODETI [4]. As a compromise, in the next version of the standard a support of standardized components will be displayed beside the anchor as a special design, as shown in (**Fig. 7**).

## Section 13.3.7: Determination of component sizes

Greater modifications were necessary in the Section "Determination of component sizes". In Section 13.3.7.3 "Stresses", the following definition is to be found:

*"The individual or equivalent stresses must not exceed the permissible stresses given in [Table 13.3.7-1] and [13.3.7-2]. The value of the combined stress $\sigma_e$ must fulfill the following equation:*

$$\sigma_e = \sqrt{(\sigma_a + \sigma_b)^2 + 4\sigma_s^2}$$

*Thereby*
*$\sigma_a$ is the calculated axial (membrane) stress*
*$\sigma_b$ is the calculated bending stress*
*$\sigma_s$ is the calculated shear stress"*

Within this brief definition two different terms "equivalent stress" and "combined stress" are used for equivalent stress. The use of the "Tresca"-equivalent stress is actually uncommon in mechanical engineering; in other rules and standards (VGB R510 L [13], KTA 3205.3 [14]) the determination of the "von-Mises" equivalent stress is required. In the revision of this section the normally-used symbol "τ" was used for shear stress. In the latest internal working version distributed in the TC 267, the standard (English version) is found as a definition of the equivalent stress:

$$\sigma_e = \sqrt{(\sigma_a + \sigma_b)^2 + 3\tau^2}\ .$$

The permissible stresses are defined in Section 13.3.7.2. It is a question thereby of two different definitions:

$$f = \min\left(\frac{R_{p0.2}}{1.5}; \frac{R_m}{2.4}\right)$$

(design in the yield stress range / time-independent design) and

$$f = \frac{f_{CR}}{1.25}$$

(for components with a design temperature in the creep range / time-dependent design)

For components designed in the yield stress range (time-independent design) the usual safety level is required. The permissible stress in the creep range (time-dependent design) "$f_{CR}$" is defined in Section 5 [Eq. 5.3.2-1]:

$$f_{CR} = S_{R\ 200{,}000t} / 1.25$$

with $S_{R\ 200{,}000t}$ as the mean creep rupture strength according to the material standard at calculation temperature t and an observed life of 200,000h (whereby the usual deviation of max. ± 20 % of the mean value is required).

The permissible stress in the creep range is thereby

- $f_{CR}$ = 0.8 mean creep rupture strength at 200,000h or
- $f_{CR}$ = min. creep rupture strength at 200,000h

It is a question thereby of the usual definition for the piping calculations. For pipe supports an additional safety factor of 1.25 is required:

- f = 0.64 mean creep rupture strength at 200,000h or
- f = 0.8 min. creep rupture strength at 200,000h

This requirement is definitely unusual and leads to unnecessarily oversized components compared with the design according to VGB R 510 L. The reason for this uneconomic requirement is only evident in the following definitions. In Sections 13.3.7.3 and 13.3.7.4 different permissible stresses are defined for "linear supports" and "plate and shell supports". The definitions of the two different types are:

*"Linear supports can be calculated according to the beam theory and the relevant permissible stresses must correspond to [Table 13.3.7-1].*

*Plate and shell supports are made from flat bars and plates and cannot be calculated according to the beam theory; the relevant permissible stresses must correspond to [Table 13.3.7-2]".*

In **Table 4** the permissible stresses from [Table 13.3.7-1] and [Table 13.3.7-2] "for normal operating conditions" are compared.

A direct comparison shows that by application of the shell / plate theory the permissible bending stress lies 50% above the usual level.

**Tab. 4:** Zulässige Spannungen für normale Betriebsbedingungen (akt. Norm)
**Table 4:** Permissible stress for normal operating conditions (act. Standard)

| Type of stress | | Permissible stresses (normal operating conditions) | | |
|---|---|---|---|---|
| | | Linear supports | Plate and shell supports | |
| Tension | $\sigma_a$ | 1.0 f | 1.0 f | |
| Bending | $\sigma_b$ | 1.0 f | 1.5 f | (!!!) |
| Shear | $\tau$ | 0.5 f | 0.5 f | |
| Equivalent | $\sigma_e$ | 1.0 f | 1.5 f | (!!!) |

**Tab. 5:** Zulässige Spannungen für normale Betriebsbedingungen (Änderungsvorschlag)

**Table 5:** Permissible stress for normal operating conditions (modification proposal)

| Type of stress | | Permissible stress (normal operating conditions) |
|---|---|---|
| Tension | $\sigma_a$ | 1.0 f |
| Bending | $\sigma_b$ | 1.0 f |
| Shear | $\tau$ | 0.6 f |
| Equivalent | $\sigma_e$ | 1.0 f |

On closer observation the following stress level is produced with the definition of f (f = $f_{CR}/1.25$):

- 1.5 f = 0.96 mean creep rupture strength at 200,000h or
- 1.5 f = 1.2 min. creep rupture strength at 200,000h.

These factors actually speak for themselves and need no further explanation. The reason for these "questionable" definitions is their 1:1 adoption from the French standard CODETI.

The German modification proposal no longer differentiates between the applied calculation theory; the permissible stress is defined as usual as:

$$f = \min\left(\frac{R_{p0.2}}{1.5}; \frac{R_m}{2.4}; f_{CR}\right)$$

The limits shown in **Table 5** then result for the individual stresses.

The modification of the max. shear stress is thereby the consequence from the change from the "Tresca" equivalent stress to the "von-Mises" equivalent stress. The permissible stresses for occasionally operating conditions amount to 1.2 times the permissible stresses for normal operating conditions.

For pipe supports NOT used in the creep range (time independent design), higher bending and equivalent stresses are permissible:

- For pipe supports analyzed with the plate or shell theory
  normal operating conditions:
  ➔ $\sigma_b \leq 1.5$ f, $\sigma_e \leq 1.5$ f
- For double symmetrical solid sections
  normal operating conditions:
  ➔ $\sigma_b \leq 1.1$ f, $\sigma_e \leq 1.1$ f

## Section 13.5.1.2: Constant hangers/supports

In the current issue of EN 13480-3 the following requirement is made in Section 13.5.1.2 "Constant hangers/supports":

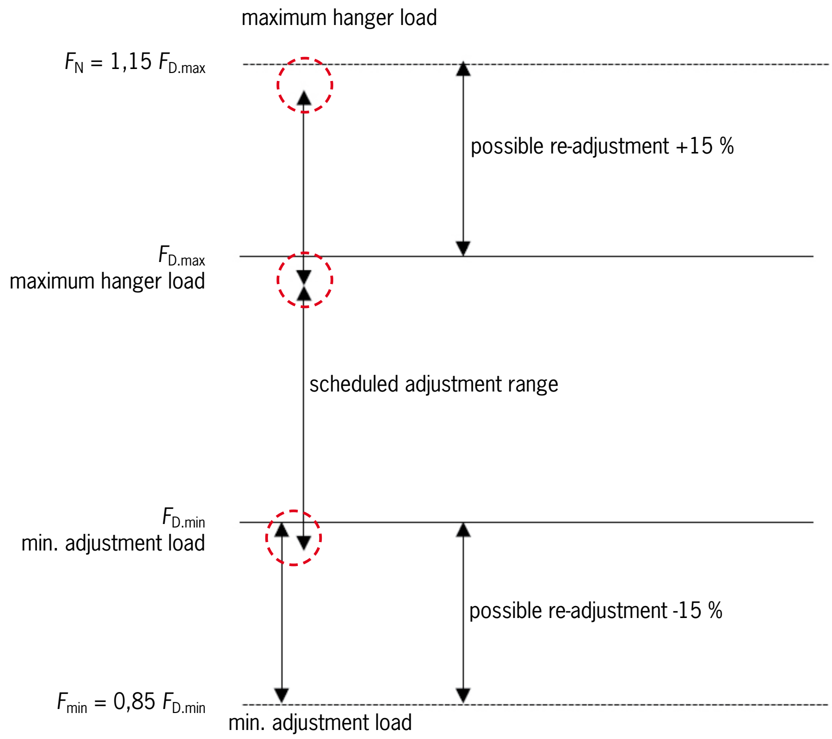



**Bild 8:** Einstellbereich für Konstantstützen [Bild I.1-2]

**Fig. 8:** Adjustment range for constant load support [Figure I.1-2]

*"Constant hangers/supports must be able to resist lateral thrusts of up to 30% of the nominal load. If higher lateral thrusts are expected, then the use of sliding surfaces should be considered in the design."*

The requirement "Constant hangers must resist a lateral thrust of 30%" is unrealistic, as the deflection of the tension rods is limited to 4° - that corresponds to approx. 7% of the vertical load. In this section the German and English versions of the standard differ. In the English versions only "base mounted supports" are mentioned. The requirement "30% lateral thrust/load" is, compared with German regulations, unusual and unrealistic. Theoretically, constant supports can be considered for such high lateral thrusts. Due to the internal friction they would have a hysteresis exceeding the usual requirement "load deviation max. ± 5%". All conceivable design measures (independently of the hanger's function principle) would be out of all proportion to the use of suitable sliding surfaces (e.g. PTFE).

The following formulation was proposed by the German mirror committee: *"Constant hangers must be designed for oblique tension of 4 %.*

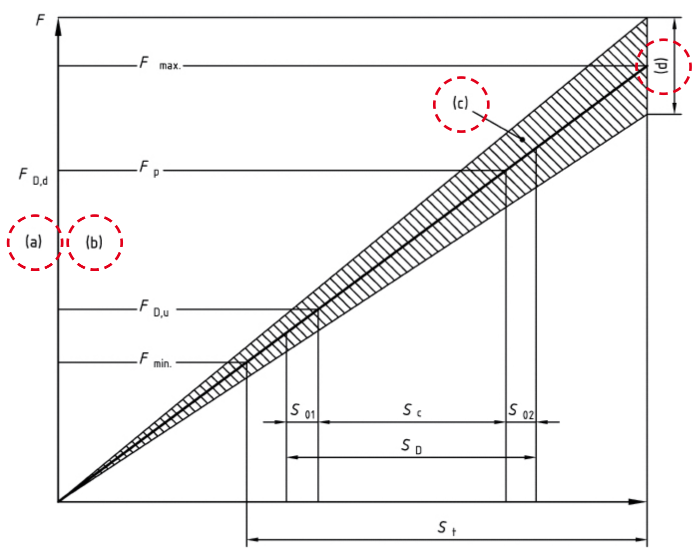
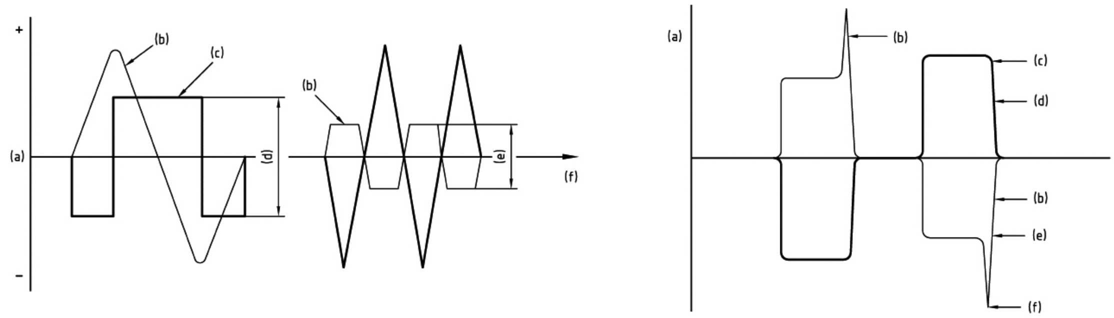



**Bild 9:** Einstellbereich für Federstützen [Bild I.2-1]

**Fig. 9:** Adjustment range for variable spring supports [Figure I.2-1]




(a) Displacement/force
(b) Displacement
(c) Force

d) Damping force
(e) Free stroke
(f) Time

(a) Speed/force
(b) Speed
(c) Nominal load
(d) Force

(e) Deaeration speed
(f) Activation speed
(g) Speed

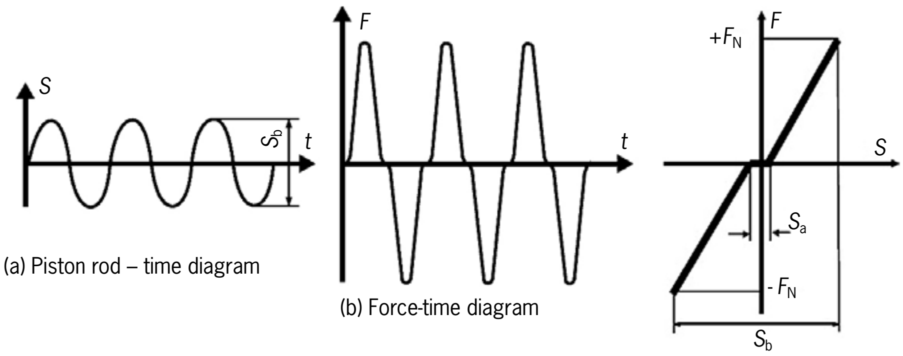
a) Testing of damping force

b) Testing of free travel

c) Testing of activation speed

**Bild 10:** Typische Prüfkurven von Schwingungsdämpfern [Bild I.3-1] (akt. Norm)

**Fig. 10:** Typical test curves for shock arrestors [Figure I.3-1] (act. Standard)




(a) Piston rod – time diagram

(b) Force-time diagram

(c) Schematic force-stroke diagram

**Bild 11:** Typische Prüfkurven von Stoßbremsen [Bild I.3-1] (Änderungsvorschlag)

**Fig. 11:** Typical characteristics of shock arrestors [Figure I.3-1] (modification proposal)

The most difficult diagram to understand is **Fig. 10** [Fig. I.3-1]. The German subtitle is: *"Typische Prüfkurven von Schwingungsdämpfern"* ("typical test curve of vibration dampers"), in the English version we find *"Typical test curves for shock arrestors"* whereby shock arrestors (shock absorbers) and vibration dampers are different components. In the upper part, the diagram shows two force-time or stroke-time diagrams. The subtitle in the English version is "(a) Drag force test" and "(b) Lost motion test". A better translation of "Drag force test" would be *"Messung des Verstellwiderstandes"*. The second diagram aims to show the *"Activation speed test"*. None of the three diagrams correspond to the usual representations. In the next issue of the standard, diagrams (**Fig. 11**) will be used as found in KTA 3205.3 and VGB R 510 L.

*Constant supports must resist a lateral load of 10% of the theoretical load. If lateral displacement occurs, suitable sliding surfaces should be provided."*

### Section 13.5.2.2 Base-mounted variable spring supports

An unrealistic requirement is also to be found in Section 13.5.2.2:

*"Spring supports must be able to resist lateral thrusts of up to 30% of the nominal load. If higher lateral thrusts are expected, then the use of sliding surfaces should be considered in the design."*

For spring supports too, the requirement '30% lateral thrust' would lead to unrealistic designs with very high hysteresis. The use of suitable sliding surfaces would be more meaningful. The modification proposal of the German TC267 delegation is as follows:

*"Spring hangers must be designed for oblique tension of 4 %. Constant supports must resist a lateral load of 10% of the theoretical load. If lateral displacement occurs, suitable sliding surfaces should be provided".*

## Annex I: Production testing of spring supports and shock arrestors

The figures in Annex I were revised. Apart from a few wrongly positioned arrows in **Fig. 8** "Adjustment range for constant load support [Figure I.1-2], the illustration was only revised editorially, the new title is "Adjustment range for constant hangers/supports". The figure no longer contains texts; they are placed under or beside the illustration as a legend, as is the standard with all other illustrations.

In **Fig. 9** the "Adjustment range for variable spring supports [Figure I.2-1] is defined, the new title is: "Adjustment range for variable spring hangers/supports". Two explanations, "(a) Downward movement of the hanger" and "(b) Upward movement of the hanger" are wrongly placed. The letters "(c)" and "(d)" are to be found in the diagram, but are not mentioned in the German issue of EN 13480-3. In the English issue we find "(c) Tolerance field" and "(d) Permitted spring rate tolerance" at this place.

## Annex J: Type testing of support components

In the normative Annex J a type test of "Support components" is defined. In contrast to the suitability test according to KTA 3205.3 or the type test according to VGB R 510 L, the function or function data (e.g. load deviations of spring and constant hangers) are not examined in the type testing. The type testing determines only the permissible rated load. The requirement is:

*"As permissible rated load, the smallest test load determined is to be used in which the ultimate failure limit (ultimate failure load FU), yield limit (yield load FY) or buckling limit (buckling load FB) is reached, whereby the lowest value according to [Table J.4-1] is to be applied for the corresponding component.*

**Table 6** defines the "Rated load derived by testing" [Table J.4-1]. At first glance this table reminds us of German codes. However, the last line but one is strange: buckling safety of 4 or 2.4 $K_1$ is demanded for "anchor tension rods" thereby $K_1$ is the ratio between the tensile strength of the material used and the values in the material standard. The physical relationship between "buckling" and "tensile strength" is not easy to detect. A look at the English version shows that instead of "anchor tension rods" the term "rods" is used, whereby tension rods are meant. In this connection a buckling load is really meaningless.

A number of clearer formulations were therefore included in the revision.

*"As permissible rated load the smallest test load determined is to be used in which the failure limit (ultimate failure load $F_U$), yield limit (yield load $F_Y$), buckling limit (buckling load $F_B$) or stability limit (stability load $F_S$) is reached, whereby the lowest value according to Table J.4-1 is to be applied for the corresponding component."*

In addition, an explanation in respect of the stability load was included:

*"Note: Failure through instability can occur in various forms such as buckling, lateral buckling, lateral torsional buckling, plate/shell buckling in the elastic as well as the plastic range."*

The table was adjusted to the usual requirements (**Table 7**).

**Tab. 6:** Durch Prüfung ermittelte Nennlast [Tabelle J.4-1] (akt. Norm)

**Table 6:** Rated load derived by testing (act. Standard)

| Type of support | Permissible load based on | | | |
|---|---|---|---|---|
| | Ultimate failure load | Yield load | Buckling load | |
| Rod type parts | $F_u/4.0$ or $F_u/2.4\ K_1$ | $F_y/1.6\ K_2$ | $F_b/1.6\ K_2$ | |
| Clamps | $F_u/4.0$ or $F_u/2.4\ K_1$ | $F_y/1.6\ K_2$ | $F_b/1.6\ K_2$ | |
| Rigid struts or shock absorbers | $F_u/4.0$ or $F_u/2.4\ K_1$ | $F_y/4.0$ or $F_y/2.4\ K_1$ | $F_b/2.5$ | |
| Sway braces | $F_u/4.0$ or $F_u/2.4\ K_1$ | $F_y/4.0$ or $F_y/2.4\ K_1$ | $F_b/2.5$ | |
| Anchor tension rods ⇦ | $F_u/4.0$ or $F_u/2.4\ K_1$ | $F_y/4.0$ or $F_y/2.4\ K_1$ | $F_b/4.0$ or $F_b/2.4\ K_1$ | (!!!) |
| Where | $K_1 = \frac{R_{m,\text{ tension test}}}{R_{m,\text{ material specification}}}$ | $K_2 = \frac{R_{p0,2,\text{ tension test}}}{R_{p0,2,\text{ material specification}}}$ | | |

**Tab. 7:** Durch Prüfung ermittelte Nennlast [Tabelle J.4-1] (Änderungsvorschlag)

**Table 7:** Rated load derived by testing (modification proposal)

| Type of support | Permissible load based on | | |
|---|---|---|---|
| | Ultimate failure | Yield load | *Stability load,* buckling load |
| Rigid supports | $F_U / 4.0$ or $F_U / (2.4\ K_1)$ | $F_Y / (1.6\ K_2)$ | $F_S / 2.5$ |
| Hanger clamps | | | |
| Hangers | | | |
| Rigid struts | $F_U / 4.0$ or $F_U / (2.4\ K_1)$ | $F_Y / (1.6\ K_2)$ | $F_B / 2.5$ |
| Shock absorbers | | | |
| Sway braces | | | |
| Compression loaded pipe supports | | | |

## Annex L: Buckling of rod-like supports

The informative Annex L treats buckling of rod-like supports. The reader can be confused in the fundamental equations by unfortunately chosen symbols or by typing errors. The radius of gyration is as usual defined as $\rho = \sqrt{I / A}$ . The buckling length of the rod-like support is calculated as $l_b = K\, l$ (with K = {0.5; 0.7;1;2}). Here the length "L" of the support should be used. The slenderness ratio is defined as $\lambda = l_b / \rho$ and is to be smaller than 200. The calculation procedure distinguishes between elastic buckling and plastic or elastoplastic buckling. Elastic buckling begins at slenderness ratios $\lambda \geq \lambda_c$. The permissible compression stress is defined for both ranges:

$$\lambda_c = \sqrt{\frac{2\pi^2 E}{R_{p0,2}}}\,.$$

$$\sigma_a(\lambda \geq \lambda_c) = \frac{12}{23}\left(\frac{\pi^2 E}{\lambda^2}\right)$$

$$\sigma_a(\lambda < \lambda_c) = \frac{R_{p0,2}\left(1 - \frac{1}{2}\left(\frac{\lambda}{\lambda_c}\right)^2\right)}{\left(\frac{5}{3} + \frac{3}{8}\left(\frac{\lambda}{\lambda_c}\right) - \left(\frac{\lambda}{\lambda_c}\right)^3\right)}$$

The formula $\sigma_a$ ($\lambda < \lambda_c$) contains an error: in the last term, in the denominator the factor 1/8 is missing. By comparing different codes, e.g. ASME BPVC [5] and AISC [6] (USA) RCCM [7] CODETI [4] (FR) it is clear that this error has crept in from the inclusion of the equations in the French standard CODETI. The representation of the two equations as a diagram reveals the mistake (**Figure 12**).

The diagrams in [Table L.5-1] had in large part to be revised, as the boundary values of the buckling-deflection lines were unclearly or wrongly presented. As an example, a variant of the third Euler buckling case (rotational spring instead of rigid fixation) is shown. At both ends the buckling-deflection line is shown with a horizontal tangent, but an inclination of the deflection line is possible at both base supports (**Figure 13**).

The correction of the last section of Annex L is particularly complex: "Checking of buckling safety for components which at the same time are loaded with axial compression stress and bending moments."

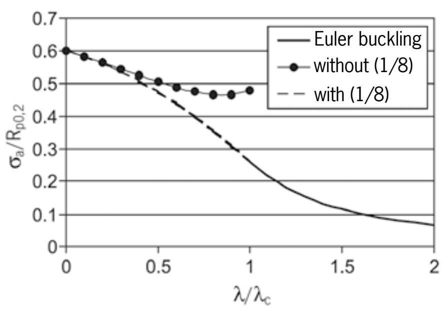



**Bild 12:** Zulässige Druckspannung in Abhängigkeit vom Schlankheitsgrad

**Fig. 12:** Permissible compression stress in dependence of slenderness ratio

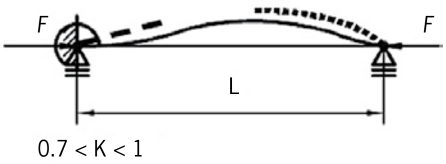



**Bild 13:** Darstellung der Knickbieglinie - aus [Tabelle L.5-1]

**Fig. 13:** Picture of buckling-bending line – taken from [Table L.5-1

For components loaded in this way the following two equations [L.5-1] and [L.5-2] must be observed:

$$\frac{f_a}{\sigma_a} + \frac{C_{m,x}\; f_{b,x}}{\left(1-\frac{f_a}{\sigma_{cr,x}}\right)F_b} + \frac{C_{m,y}\; f_{b,y}}{\left(1-\frac{f_a}{\sigma_{cr,y}}\right)F_b} \le 1{,}0 \qquad [L.5\text{-}1]$$

and

$$\frac{f_a}{0.6\;R_{p0,2}} + \frac{f_{b,x}}{F_b} + \frac{f_{b,y}}{F_b} \le 1.0 \quad [L.5\text{-}2]$$

Annex L ends with the definition of the equations. The user must have wide experience of foreign codes to recognize that with "f", calculated stresses, and with "F", permissible stresses are meant. This nomenclature does not accord with the first part of the standard. The indices "x" and "y" denote the bending axes of the beam, "x" is normally the longitudinal axis of the beam. Altogether all the other eight symbols of the [Eq. L.5-1] are not defined, except for $\sigma_a$.

## Annex N: Documentation for pipe supports

In Annex N the rules for the documentation of pipe supports are set out. The 2002 issue thereby makes the classifications material, design, manufacture, testing and certification for the three support classes S1 – S3. The requirement are kept fairly general; for example, for Class 3 pipe supports, all materials are to be supplied with inspection certificates 3.1, independently of the working/operating temperature, for example. Annex N was revised on the basis of a German modification proposal, to be formed in the European agreement as EN 13480-3:2002 / prA5:2007. In this proposal the documentation (inspection certificate) is itemized in detail according to the product shapes e.g. springs, welding consumables, welding fillers, sheet metal, connections and small parts. The operating temperature as in VGB R 510 L, is thereby taken into account. In the second part of the table (design, manufacture, testing and certification), references were included in Annex I (production testing of spring supports and shock absorbers) and Section 13 (pipe supports).

## Section 11: Integral attachments

In Section 11 the stress determination for hollow circular and rectangular attachments is defined. Shear lugs and trunnions actually belong to the piping and not to the pipe supports, but this interface between pipe stress analysis and pipe support design is not free of repercussions. The calculation method is well known from various other codes (e.g. ASME Code Cases N-392-3 and N-318-5 [8]). The German modification proposal comprises four points.

### Proposal 1: Restructuring of the code

The Section "Integral attachments" should be placed after the section "Stress analysis", as the stress analysis output data supply the input data for calculation of the attachments. (This was not done, at the request of the French delegation).

### Proposal 2: Correction of the "clerical errors"

In the formulae of Chapter 11 there are a number of clerical errors – DIN EN 13480-3 correction 2 also contains some mistakes. As examples, only the corrections to equation [11.3.5-2] are mentioned here.

Mn not W

$$\sigma_{NT} = \frac{C_W\,W}{A_T} + \frac{C_N\,W}{Z_N} + \frac{C_L\,M_L}{Z_T} + \frac{Q_1}{A_m} + \frac{Q_2}{A_m} + \frac{C_T\,M_T}{\bar{J}}$$

$Z_T$ J not $\bar{J}$

### Proposal 3: Rearrangement of the section

As an aid to users and for easier application Section 11 is to be rearranged. The calculation methods for hollow circular and rectangular attachments are to be summarized in a single section in each case.

### Proposal 4: Integrated attachments in the creep range

In the current version of the code the calculated stresses for the run pipe, the attachment and the weld seam are secured against the yield stress. For the creep range, corresponding stress limits are to be included.

The additional relation is included for the run pipe:

*The following equation limits the stresses in the pipe wall to the median value of the creep range in a similar way to [Eq. 12.3.5-1].*

$$\sigma_5 = \frac{p_c D_o}{4e_n} + 0{,}75\left(\frac{i\cdot M_A}{Z} + \frac{i\cdot M_C}{3Z}\right) + \sigma_{MT} + \frac{\sigma_{PT}}{2}$$

$\le 1.25\ f_{cr}$
with
$0.75\ i \ge 1$,

$\sigma_{MT}$, $\sigma_{PT}$; additional stresses resulting from dead weight, constantly acting loads and loading due to restricted thermal expansion.

A further condition limits the maximum stress in the attachment.

*In the creep range, the equivalent stress is to be limited to a value smaller or equal to the median value of the creep range:* $\sigma_{NT}^{**} \le 1.25\ f_{cr}$

One condition in each case for trunnions/shear lugs limits the resulting shear stress in the attachment or weld seam:

- *For trunnions in the creep range, the resulting shear stress is limited to the average value of the shear creep strength dep. on time according to the von-Mises hypothesis:*

$$\frac{\sqrt{(Q_1^{**})^2 + (Q_2^{**})^2}}{A_m} + \frac{M_T^{**}}{J} \le \frac{1.25}{\sqrt{3}}\cdot f_{cr}\,.$$

- *For rectangular attachments in the creep range the resulting shear stress is limited to the average value of the shear creep strength dep. on time according to the von-Mises hypothesis:*

$$\sqrt{\left(\frac{Q_1^{**}}{2\,L_1\,L_a}\right)^2 + \left(\frac{Q_1^{**}}{2\,L_1\,L_b}\right)^2 + M_{TT}^{**}}$$
$$\le \frac{1.25}{\sqrt{3}}\cdot f_{cr}\,.$$

## Section 12: Flexibility analysis and acceptance criteria (12.2.8 Support conditions)

In Section 12.2.8 the support or boundary conditions are defined for the pipe system calculations. In the German translation, unfortunately, the usual terms are not used. Two examples will serve to show how readers who occupy themselves largely with pipe system calculations can be left in some confusion. In the current issue of the standard the following definitions are to be found:

- *"Typische Abstützungen sind: Halterungen: Abstützungen, die Kräften und Momenten in allen Richtungen standhalten, z. B. Verankerungen;"*

("Typical supports are: supports which withstand all forces and moments in all directions, e.g. anchors")

The use of common terms improves readability:

- "Typical pipe supports are: fixed points: pipe supports which absorb forces and moments in all directions."

A further example of an unfortunate choice of words:

■ *"Abstützungen mit variabler Stützkraft: Abstützungen, deren Fähigkeit zur Aufnahme von Kräften und Momenten in linearer Beziehung zu Federsteifigkeit und Verformung steht;"*

("Supports with variable supporting force: supports whose capacity to absorb forces and moments stands in linear relation to spring rate and deformation.")

In general, spring hangers or spring supports are thereby meant: rotational springs are more seldom used. The term "Verformung" ("deformation") is not a happy choice either, but it is the literal translation of the English term "deformation". A better formulation is:

■ "Pipe support with variable force: Pipe support whose capacity to absorb forces stands in linear relation to spring stiffness and displacement."

The further definitions in this section will also differ slightly from the current version in the next issue of the standard.

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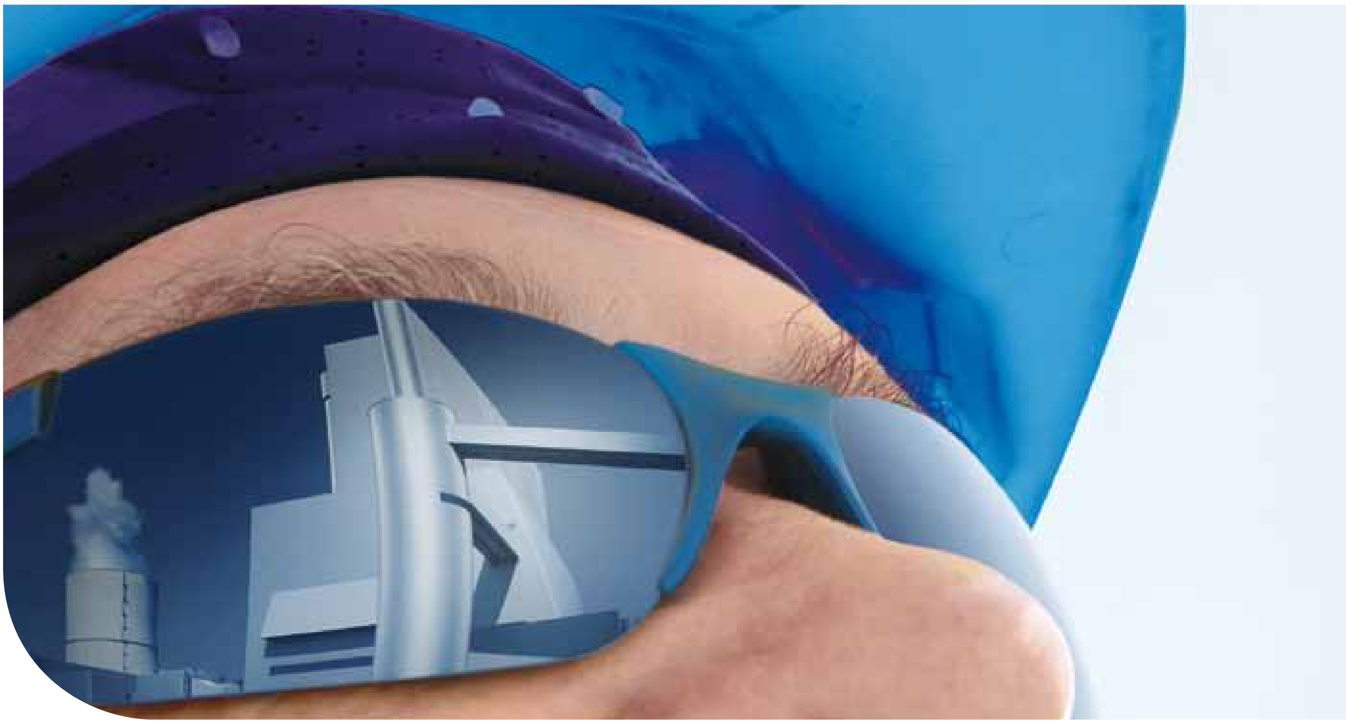

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