



BSI Standards Publication

Metallic industrial piping

Part 3: Design and calculation

National foreword

This British Standard is the UK implementation of EN 13480-3:2017+A5:2022. It supersedes BS EN 13480-3:2017+A4:2021, which is withdrawn.

The text of CEN amendments A2:2020, A3:2020, A1:2021, A4:2021 and A5:2022 has been provided in its entirety at the beginning of this document. BSI's policy of providing consolidated content remains unchanged; however, in the interest of expediency, in this instance BSI have chosen to collate the relevant content at the beginning of this document.

The UK participation in its preparation was entrusted to Technical Committee PVE/10, Piping systems.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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English Version

Metallic industrial piping - Part 3: Design and calculation

Tuyauteries industrielles métalliques - Partie 3 :
Conception et calcul

Metallische industrielle Rohrleitungen - Teil 3:
Konstruktion und Berechnung

This amendment A2 modifies the European Standard EN 13480-3:2017; it was approved by CEN on 12 July 2020.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

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European foreword

This document (EN 13480-3:2017/A2:2020) has been prepared by Technical Committee CEN/TC 267 “Industrial piping and pipelines”, the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 2021, and conflicting national standards shall be withdrawn at the latest by February 2021.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a standardization request given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of EN 13480-3:2017.

This document includes the text of the amendment itself. The amended/corrected pages of EN 13480-3:2017 will be published as Issue 4 of the European Standard.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Modification to 3.2, "Symbols and units"

Table 3.2-1 shall be completed with the line e_c to be placed after e_n :

e_c	corroded thickness (see Figure 4.3–1 and Figure 4.3–2)	mm
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2 Modification to 4.2, "Loadings"

The second sentence of subclause 4.2.4.6 shall read as follows:

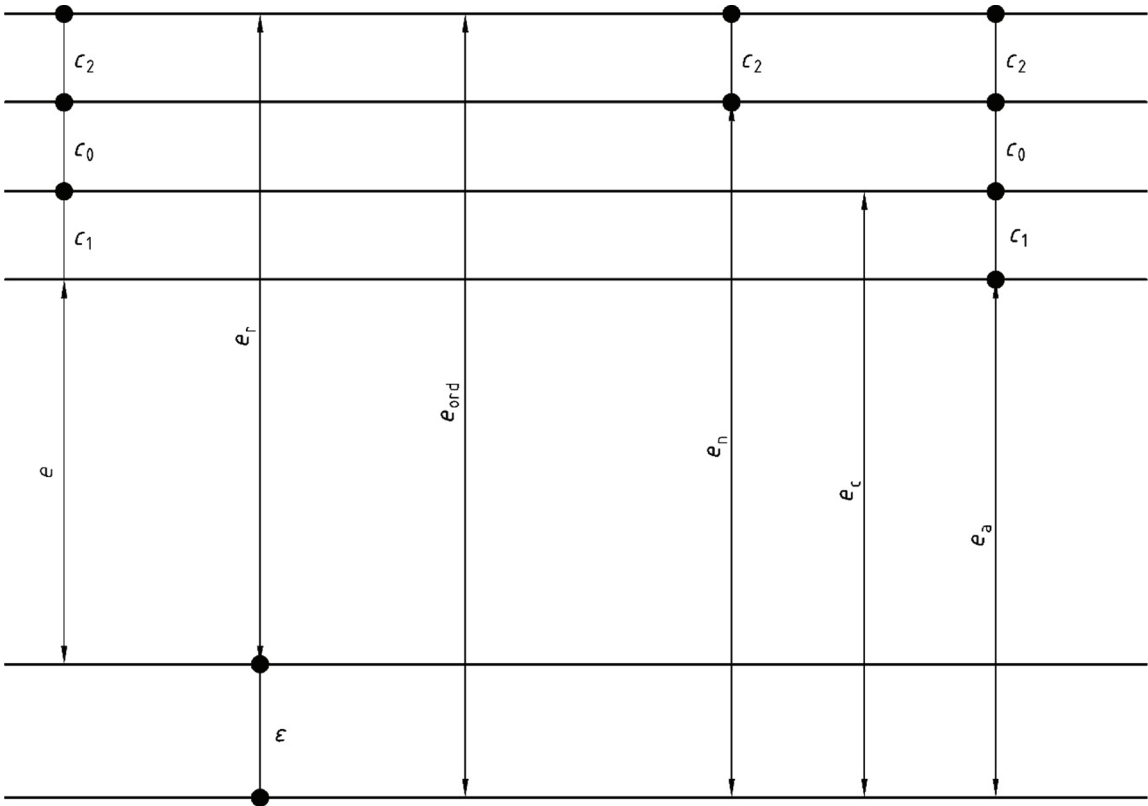
"The specification shall give details relating to the characteristics of the seismic conditions (design basis earthquake and/or safe shut-down earthquake) to be taken into account."

The last indent of 4.2.5.2.1 shall read as follows:

"— seismic conditions (Design Basis Earthquake)."

3 Modification to 4.3, "Thickness"

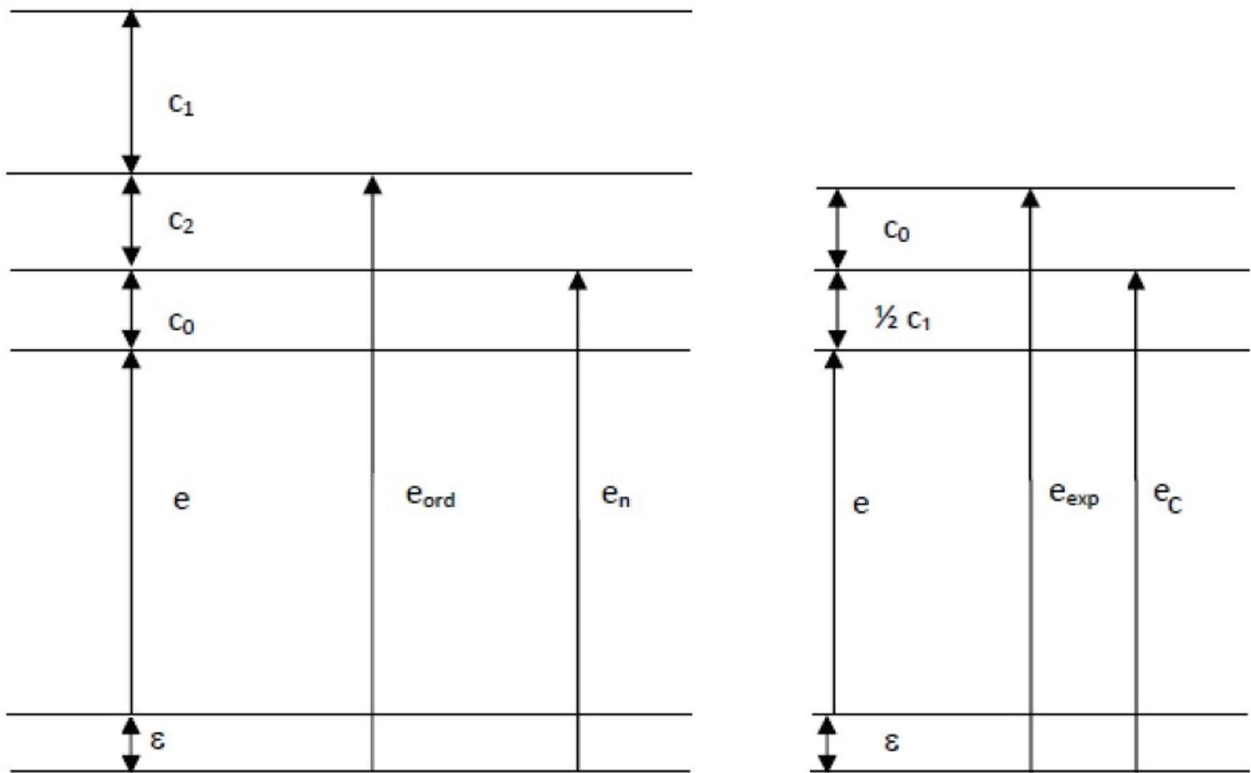
The new Figure 4.3-1 shall read as follows:



The key of Figure 4.3-1 shall be updated with the following correction and addition:

- c_2 is the thinning allowance for possible thinning during manufacturing process;
- e_c is the wall thickness after corrosion or erosion used for flexibility analysis in Clause 12;

The new Figure 4.3-2 shall read as follows:



The key of Figure 4.3-2 shall be updated with the following correction and addition:

- c_2 is the thinning allowance for possible thinning during manufacturing process;
- e_c is the wall thickness after corrosion or erosion used for flexibility analysis in chapter 12;

4 Modification to 12.2.4.2, "Overstrained behaviour"

The first indent shall read as follows:

- Where there is large deflection at the connecting point between two pipes with significantly different cross section;

5 Modification to 12.2.10.3, "Basic assumptions and requirements"

The last paragraph of subclause 12.2.10.3.1 shall read as follows:

When friction forces are significant, they shall be considered in the piping design.

6 Modification to 12.3, "Flexibility analysis"

The revised Clause 12.3.1 shall read as follows:

"12.3.1 General

The following determination and limitation of stresses shall be used to ensure the safe operation of the piping.

The Formulae (12.3.2-1) and (12.3.3-1) deal with the longitudinal stresses due to design and operating loadings, and the Formulae (12.3.4-1) and (12.3.4-2) with the stress range due to such loadings that gives rise to deformation of the total system.

In Formula (12.3.5-1), one-third of the stress resulting from thermal expansion and alternating loadings are taken into consideration with respect to the material behaviour in the creep rupture stress range, assuming that two-thirds will be relieved by relaxation.

Formula (12.3.6-1) ensures that in the event of a single non-repeated load, no strain occurs which can adversely affect the material.

The forces and moments shall be determined for nominal thickness of the pipe e_n .

The longitudinal stresses for primary loads shall be determined based on the corroded thickness e_c .

The longitudinal stresses for thermal expansion and alternating loads shall be determined based on nominal thickness e_n .

NOTE Wall thickness reductions, allowed by the technical conditions of delivery for seamless and welded pipes are covered by the stress limits.

The stress intensification factors, i , i_p , i_o , are given in Tables H-1 to H-3 and are calculated based on nominal wall e_n .

The sectional modulus of the nominal pipe is:
$$Z = \frac{\pi(d_o^4 - d_i^4)}{32d_o}$$

Unless specified otherwise, it is assumed that corrosion happens on the inside of the pipe so that the inner diameter after corrosion is $d_i = d_o - 2e_c$

and the sectional modulus of the corroded pipe is:
$$Z_c = \frac{\pi(d_o^4 - (d_o - 2e_c)^4)}{32d_o}$$

Using the alternative equations given in 12.3.2 to 12.3.6 with the corresponding stress intensification factors in Table H-3, allow a more detailed determination of the stresses by considering independently in-plane and out-of-plane moments.

For the general and the alternative route, the stress intensity factors, i , including the reduction factor 0,75, if defined, shall be greater than or equal to 1,0 ($0,75 \leq i \leq 1,0$). If a value less than 1 is obtained then the value 1,0 shall be used.

If considerable corrosion/erosion is expected, it is taken into account in the flexibility analysis as follows. In the Formulae (12.3.2-1), (12.3.2-2), (12.3.3-1), (12.3.3-2) and (12.3.4-2), using the sectional modulus based on the corroded pipe.

Optionally the corrosion may be disregarded during flexibility design, if provisions are taken in order that corrosion is detected during inspection. In this case Z and e_n shall be used instead of Z_c and e_c in these equations."

For most piping systems, the axial forces in the pipe are dominated by the internal pressure reaction force. In special cases, such as buried pipes or pipes which are otherwise restrained in axial direction, the axial stresses from external loads may be significant. In these cases, the axial force Q in Formulae 12.3.2 to 12.3.6 allows taking into account these effects.

7 Modification to 12.3.2, "Stress due to sustained loads"

The revised Clause 12.3.2 shall read as follows:

"12.3.2 Stress due to sustained loads"

The sum of primary stresses σ_1 , due to calculation pressure, p_c , and the resultant moment, M_A , from weight and other sustained mechanical loads shall satisfy the following equation:

$$\sigma_1 = \frac{i_{QA} Q_{xA}}{A_c} + \frac{0,75 i M_A}{Z_c} \leq f_f \quad (12.3.2-1)$$

where

M_A is the resultant moment from the sustained mechanical loads which shall be determined by using the most unfavourable combination of the following loads:

- piping dead weight including insulation, internals and attachments;
- weight of fluid;
- internal pressure forces due to unrelieved axial expansion joints etc.

$$Q_{xA} = \max \left(\left| Q_{xS} \right|, \left| \frac{p_c \pi d_i^2}{4} + Q_{xS} \right| \right)$$

Q_{xS} is the axial force from the sustained mechanical loads

d_i is the inner diameter of the corroded pipe

$A_c = \frac{\pi}{4} (d_o^2 - d_i^2)$ is the cross section of the pipe (reduced by the corrosion allowances)

i_{QA} is the stress intensification factor for axial forces for sustained loads. Unless more precise information is available $i_{QA} = 1,0$

i is the stress intensification factor from Table H.1

f_f is the design stress for flexibility analysis in N/mm^2 (MPa) with $f_f = \min(f; f_{cr})$.

or alternatively using the stress intensification factors from Table H.3:

$$\sigma_1 = \sqrt{\left[\frac{i_{QA} Q_{xA}}{A_c} + \frac{\sqrt{(0,75 i_i M_{iA})^2 + (0,75 i_o M_{oA})^2}}{Z_c} \right]^2 + \left[\frac{i_t M_{tA}}{Z_c} \right]^2} \leq f_f \quad (12.3.2-2)$$

where

M_{iA} is the in-plane moment from the sustained mechanical loads

M_{oA} is the out-of-plane moment from the sustained mechanical loads

M_{tA} is the torsional moment from the sustained mechanical loads

i_t is the stress intensification factor for torsional moments. Unless more precise information is available $i_t = 1,0$

For the consideration of pressure test loads in Formula (12.3.2-1), the calculation pressure p_c shall be replaced by the test pressure p_{test} (see EN 13480-5). In addition, the design stress f_f shall be replaced by a value of 95 % R_{eH} at test temperature."

8 Modification to 12.3.3, "Stress due to sustained and occasional or exceptional loads"

The revised Clause 12.3.3 shall read as follows:

"12.3.3 Stress due to sustained and occasional or exceptional loads

The sum of primary stresses, σ_2 , due to internal pressure, p_c , resultant moment, M_A , from weight and other sustained mechanical loads and resultant moment, M_B , from occasional or exceptional loads shall satisfy the following equation:

$$\sigma_2 = \frac{i_{QA} Q_x}{A_c} + \frac{0,75 i M_A}{Z_c} + \frac{0,75 i M_B}{Z_c} \leq k f_f \quad (12.3.3-1)$$

where

M_B is the resultant moment from the occasional or exceptional loads which shall be determined by using the most unfavourable combination of the following loads:

- wind loads ($T \leq T_B/10$);
- snow loads;
- dynamic loads from switching operations ($T \leq T_B/100$);
- seismic loads ($T \leq T_B/100$);

Q_x is the axial force from the sustained and occasional or exceptional loads

The axial force shall include the most unfavourable combination of the following loads:

- pressure effect (acting or not);
- sustained loads Q_{xA} (acting all the time);
- occasional or exceptional loads Q_{xB} (acting or not, reversing or not).

for reversing loads:

$$Q_x = \max \left(\left| Q_{xA} \right| + \left| Q_{xB} \right|, \left| \frac{p_c \pi d_i^2}{4} + Q_{xA} \right| + \left| Q_{xB} \right| \right) \quad (12.3.3-2)$$

for non-reversing loads:

$$Q_x = \max \left(|Q_{xA}|, |Q_{xA} + Q_{xB}|, \left| \frac{p_c \pi d_i^2}{4} + Q_{xA} \right|, \left| \frac{p_c \pi d_i^2}{4} + Q_{xA} + Q_{xB} \right| \right) \quad (12.3.3-3)$$

f_f is the design stress for flexibility analysis in N/mm² (MPa) with $f_f = \min(f; f_{cr})$.

$k = 1$ if the occasional load is acting for more than 10 % in any 24 h operating period, e.g. normal snow, normal wind;

$k = 1,15$ if the occasional load is acting for less than 10 % in any 24 h operating period;

$k = 1,2$ if the occasional load is acting for less than 1 % in any 24 h operating period, e.g. dynamic loadings due to valve closing/opening, operational basis earthquake;

$k = 1,3$ for exceptional loads with very low probability e.g. very heavy snow/wind (i.e. 1,75 times normal);

$k = 1,8$ for safe shut-down earthquake;

p_c is the maximum calculation pressure occurring at the considered loading condition, the calculation pressure shall be taken as a minimum.

or alternatively using the stress intensification factors from Table H.3:

$$\sigma_2 = \sqrt{\left(\frac{i_{QA} Q_x}{A_c} + \frac{\sqrt{[0,75 i_i (M_{iA} + M_{iB})]^2 + [0,75 i_o (M_{oA} + M_{oB})]^2}}{Z_c} \right)^2 + \left(\frac{i_t M_{tA} + i_t M_{tB}}{Z_c} \right)^2} \leq k \cdot f_f \quad (12.3.3-4)$$

where

M_B is the moment from occasional or exceptional loads with the components:

M_{iB} is the in-plane moment from occasional or exceptional loads

M_{oB} is the out-of-plane moment from occasional or exceptional loads

M_{tB} is the torsional moment from occasional or exceptional loads

For reversing loads both signs of M_B shall be considered.

The effects of anchor displacements due to earthquake may be excluded if they are included in Formula (12.3.4-1).

Unless specified otherwise, the following agreements apply:

- the action time T corresponds to the bracketed values referring to the total operating time T_B ;
- snow and wind loads are not applied simultaneously;
- loadings with $T \leq T_B/100$ are not applied simultaneously”;

9 Modification to 12.3.4, "Stress range due to thermal expansion and alternating loads"

The revised Clause 12.3.4 shall read as follows:

"12.3.4 Stress range due to thermal expansion and alternating loads"

The stress range, σ_3 , due to the resultant moment, M_C , from thermal expansion and alternating loads, e.g. seismic loads, shall either satisfy the following equation:

$$\sigma_3 = \frac{i_{QC} Q_{xC}}{A} + \frac{i M_C}{Z} \leq f_a \quad (12.3.4-1)$$

where

A is the nominal cross section of the pipe

$$= \frac{\pi}{4} (d_o^2 - d_i^2)$$

i_{QC} is the stress intensification factor for axial forces for alternating loads. Unless more precise information is available $i_{QC} = 1,0$

iM_C is the weighted range of resultant moment due to thermal expansion and alternating loads which shall be determined from the greatest difference between moments of any two load cases (j and k) using the moduli of elasticity and stress intensification factors i from Table H.1 at the relevant temperatures and pressures:

$$iM_C = \max \left(\sqrt{(i_j M_{xCj} - i_k M_{xCk})^2 + (i_j M_{yCj} - i_k M_{yCk})^2 + (i_j M_{zCj} - i_k M_{zCk})^2} \right)_{j=1 \dots N; k=1 \dots N}$$

The stress free initial state shall be included in the range calculation if relevant.

Q_{xC} is the range of axial force due to thermal expansion and alternating loads

f_a is the design stress for flexibility analysis in N/mm^2 (MPa) from Formula (12.1.3-1)

or where the conditions of Formula 12.3.4-1 are not met, the sum of stresses, σ_4 , due to calculation pressure p_C , resultant moment, M_A , from sustained mechanical loads and the resultant moment, M_C , from thermal expansion and alternating loads shall satisfy the following equation:

$$\sigma_4 = \sigma_1 + \sigma_3 \leq f_f + f_a \quad (12.3.4-2)$$

or alternatively using the stress intensification factors from Table H.3:

$$\sigma_3 = \sqrt{\left(\frac{i_{QC} Q_{xC}}{A} + \frac{\sqrt{(i_i M_{iC})^2 + (i_o M_{oC})^2}}{Z} \right)^2 + \left(\frac{i_t M_{tC}}{Z} \right)^2} \leq f_a \quad (12.3.4-3)$$

where

M_{iC} is the in-plane moment range due to thermal expansion and alternating loads

M_{oC} is the out-of-plane moment range due to thermal expansion and alternating loads

M_{tC} is the torsional moment range due to thermal expansion and alternating loads

The above equation assumes that the moment range can be calculated as the difference between one thermal expansion load case and the stress free initial condition.

In the case of multiple load situations with different temperature and pressure situations the stress range (Formula 12.3.4-4) is the maximum difference between all pairs (j,k) of thermal expansion or alternating load cases calculated in the following way:

$$\sigma_3 = \max_{j=1 \dots N; k=1 \dots N} \left(\sqrt{\left(\frac{i_{Qj} Q_{xCj} - i_{Qk} Q_{xCk}}{A} + \frac{\sqrt{(i_{ij} M_{iCj} - i_{ik} M_{iCk})^2 + (i_{oj} M_{oCj} - i_{ok} M_{oCk})^2}}{Z} \right)^2 + \left(\frac{i_{tj} M_{tCj} - i_{tk} M_{tCk}}{Z} \right)^2} \right) \leq f_a \quad (12.3.4-4)$$

where

N is the number of load cases which contribute to thermal expansion or alternating loads

i_{QL} is the stress intensification factor for axial forces in the load case L. Unless more precise information is available $i_{QL} = 1,0$

i_{iL} is the stress intensification factor for in-plane moments in the load case L taken from Table H.3 using the relevant operation conditions

i_{oL} is the stress intensification factor for out-of-plane moments in the load case L taken from Table H.3 using the relevant operation conditions

i_{tL} is the stress intensification factor for torsional moments in the load case L. Unless more precise information is available $i_{tL} = 1,0$

M_{iCL} is the in-plane moment in load case L

M_{oCL} is the out-of-plane moment in load case L

M_{tCL} is the torsional moment in load case L

or where the conditions of Formula 12.3.4-4 are not met, the sum of stresses, σ_4 , due to calculation pressure p_C , resultant moment, M_A , from sustained mechanical loads and the resultant moment, M_C , from thermal expansion and alternating loads shall satisfy the Formula (12.3.4-2).

Particular attention shall be given to:

- longitudinal expansion, including terminal point movements, due to thermal expansion and internal pressure;
- anchor point movements due to earthquake if anchor displacement effects were omitted from Formula (12.3.3-1) or (12.3.3-2);
- anchor point movements due to wind;
- frictional forces.

The condition of the piping during shut-down shall be also considered. Cold pull, if any, applied during installation shall not be taken into account, i.e. the operating case pertinent to M_C shall be so designed as if no cold pulling was applied unless the cold state including cold pull is also considered in the calculation of the stress range."

10 Modification to 12.3.5, "Additional conditions for the creep range"

The revised Clause 12.3.5 shall read as follows:

"12.3.5 Additional conditions for the creep range"

For piping operating within the creep range, the stresses, σ_5 , due to calculation pressure, p_C , resultant moment, M_A , from weight and other sustained mechanical loadings, and to resultant moment, M_C , from thermal expansion and alternating loadings, shall satisfy the following equation:

$$\sigma_5 = \sigma_1 + \frac{i_{QC} Q_{xC}}{3A} + \frac{0,75 i M_C}{3Z} \leq f_{CR} \quad (12.3.5-1)$$

or alternatively using the stress intensification factors from Table H.3:

$$\sigma_5 = \sigma_1 + \sqrt{\left[\frac{i_{QC} Q_{xC}}{3A} + \sqrt{\left(0,75 i_i \frac{M_{iC}}{3Z} \right)^2 + \left(0,75 i_o \frac{M_{oC}}{3Z} \right)^2} \right]^2 + \left[\frac{i_t M_{tC}}{3Z} \right]^2} \leq f_{CR} \quad (12.3.5-2)$$

In Formula (12.3.5-1), one-third of the moment M_C is considered with respect to the material behaviour in the creep rupture stress range, unless confirmed otherwise by detailed inelastic analysis."

11 Modification to 12.3.6, "Stresses due to a single non-repeated support movement"

The revised Clause 12.3.6 shall read as follows:

"12.3.6 Stresses due to a single non-repeated support movement"

Where the design stress as given in Clause 5 is time-independent, the stress, σ_6 , due to resultant moment, M_D , from a single non-repeated support movement, shall satisfy the following equation:

$$\sigma_6 = \frac{i_{QD} Q_{xD}}{A} + \frac{i M_D}{Z} \leq f_D \quad (12.3.6-1)$$

where

M_D	is the resultant moment from a single non-repeated anchor/restraint movement e.g. terminal point movements due to settlement of buildings, or due to damage caused by mining.
i_{QD}	is the stress intensification factor for axial forces for single non repeated support movement load. Unless more precise information is available, $i_{QD} = 1,0$
Q_{xD}	is the axial force due to non-repeated anchor/restraint movement
$f_D = \min (R_m ; 2R_{p0,2t})$	for ferritic steels and austenitic steels with A < 30 %

$$f_D = \min (R_m ; 2R_{p1.0 \text{ t}}) \quad \text{for austenitic steels with } A \geq 30 \%$$

or alternatively using the stress intensification factors from Table H.3:

$$\sigma_6 = \sqrt{\left(\frac{i_{QD} Q_{xD}}{A} + \frac{\sqrt{(i_i M_{iD})^2 + (i_o M_{oD})^2}}{Z} \right)^2 + \left(\frac{i_t M_{tD}}{Z} \right)^2} \leq f_D \quad (12.3.6-2)$$

where

- M_{iD} is the in-plane moment due to non-repeated anchor/restraint movement
- M_{oD} is the out-of-plane moment due to non-repeated anchor/restraint movement
- M_{tD} is the torsional moment due to non-repeated anchor/restraint movement

Where the design stress as given in Clause 5 is time-dependent, the calculated stress shall not exceed the following:

- 0,3 times 0,2 % proof strength for ferritic steels at the calculation temperature;
- 0,3 times 1,0 % proof strength for austenitic steels at the calculation temperature.

NOTE It is possible that a small part of the piping system will undergo considerable inelastic strain when the rest of the system is almost entirely elastic. This happens when the part concerned is appreciably weaker than the rest, either due to reduced section size, weaker material or higher temperature. Conditions likely to cause significant inelastic strain should preferably be avoided. If this is not possible, a more complete inelastic analysis should be undertaken.”

12 Modification to 12.3.7, "Determination of resultant moments"

The revised Clause 12.3.7 shall read as follows:

“12.3.7 Determination of resultant moments

When determining the moment values M_A , M_B , M_C and M_D , used in equations given in 12.3.2 to 12.3.6, the following basic rules shall be considered.

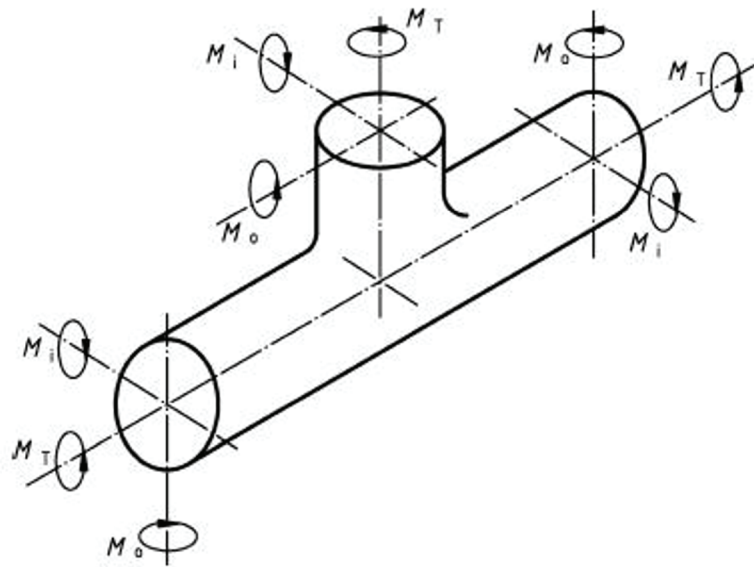
For n simultaneously applied moments M_i ($i = 1, 2, \dots, n$) with the coordinates M_{xi} , M_{yi} , M_{zi} referred to a right-angle coordinate system x, y, z the total resultant moment M is the sum of moments:

$$\vec{M} = \begin{pmatrix} M_x \\ M_y \\ M_z \end{pmatrix} = \begin{pmatrix} \sum_{i=1}^n M_{xi} \\ \sum_{i=1}^n M_{yi} \\ \sum_{i=1}^n M_{zi} \end{pmatrix} \quad (12.3.7-1)$$

and

$$M = \sqrt{M_x^2 + M_y^2 + M_z^2} \quad (12.3.7-2)$$

Examples for moments on a T-piece and on a bend are given in Figures 12.3.7-1 and -2.

**Key**

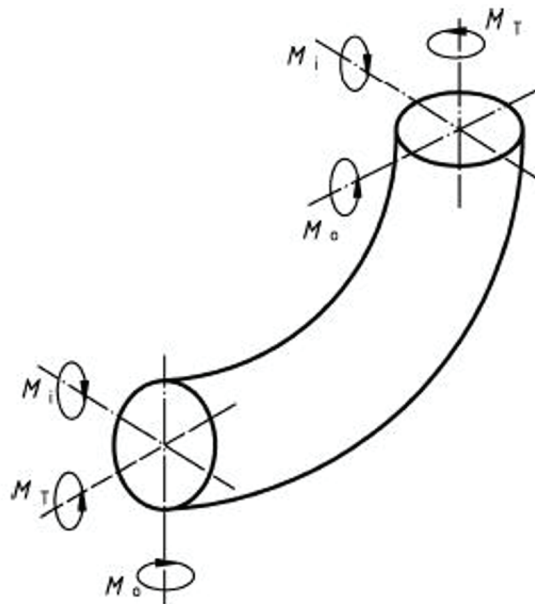
M_o is the out-of-plane bending moment;

M_i is the in-plane bending moment;

M_T is the torsional moment;

M_R is the resultant moment $\sqrt{M_o^2 + M_i^2 + M_T^2}$

Figure 12.3.7-1— Moments on a T-piece



Key

M_o is the out-of-plane bending moment;

M_i is the in-plane bending moment;

M_T is the torsional moment;

M_R is the resultant moment $\sqrt{M_o^2 + M_i^2 + M_T^2}$

Figure 12.3.7-2 — Moments on a bend

13 Modification to 12.3.8, "Alternative method for stress calculation"

Clause 12.3.8 shall be deleted and the current Clause 12.3.9 "Reactions" shall be renumbered 12.3.8.

14 Modification to 13.1.1, "General"

In 13.1.1, the first paragraph shall read as follows:

"Clause 13 specifies the requirements for supporting and controlling the movement of piping systems subject to the requirements of EN 13480. Clause 13 is organized into logical sequence to help the user:

- general definitions and remarks,
- selection of pipe supports,
- design, manufacture and test requirements.

In 13.1.1, the last indent shall read as follows:

"— direct and transfer static (or dynamic if they occur) loadings from the pipe to the surrounding structure and shall limit or restrain one or more of the six degrees of freedom at a specific point of the piping system."

15 Modification to 13.1.3.12,

Definition 13.1.3.12 shall read as follows:

"13.1.3.12**support designer**

person or company designing the complete pipe supports and generating the support drawings, responsible to select the correct standard pipe support components".

16 Modification to 13.1.3.13, "Pipe support manufacturer"

Definition 13.1.3.13 shall read as follows:

"13.1.3.13**pipe support manufacturer**

producer of the pipe support components (e.g. hangers, clamps, threaded parts), responsible for the design of these components (often the designer and the manufacturer of the pipe support components are one and the same)".

17 Modification to 13.1.3.14, "Main structure designer"

Definition 13.1.3.14 shall read as follows:

"13.1.3.14**main structure designer**

person or company responsible for the main structure of the building (civil engineers)".

18 Modification to 13.1.3.16, "Occasional load"

Definition 13.1.3.16 shall read as follows:

"13.1.3.16**occasional load**

load resulting from load conditions defined in 4.2.5.2 (occasional operating conditions) and in 4.2.5.4 (test conditions)".

19 Modification to 13.2.1, "General"

The second sentence of 13.2.1 shall read as follows:

"Standardised supports are generic components which have proven load capacities and are catalogued."

The NOTE 2 of 13.2.1 shall read as follows:

"NOTE 2 Special consideration may be needed for supports close to sensitive equipment (e.g. rotating machinery) or where the piping would exert unacceptable loads on the equipment connected to it."

20 Modification to 13.2.2, "Detail design of pipe supports"

The first sentence of 13.2.2.3 shall read as follows:

"All hanger type supports shall be provided with means of length adjustment."

The paragraph of 13.2.2.6 shall read as follows:

"The connection of pipe supports to the main structure shall be communicated by the piping designer / support designer to the main structure designer, who shall ensure that all loadings imposed on the

structure by the piping (including frictional forces) are within acceptable limits (see Annex K for examples).".

21 Modification to 13.3.6, "Identification Marking/Name plate"

In the list, the 10th indent shall read as follows:

— load adjustment scale (in N, kN or percentage of calibrated load, unless otherwise specified);

22 Modification to 13.5, "Rigid struts"

The second indent of 13.5 shall read as follows:

— rigid struts shall be fitted with spherical bearings at the ends. The bearings shall have minimal free play and allow a minimum of 6 ° of rotation from the operating plane";

23 Modification to 13.6, "Shock arrestors, shock absorbers (snubbers)"

The fifth indent of 13.6 shall read as follows:

— the shock arrestors shall be fitted at each end with spherical bearings. The bearings shall have minimal free play and allow a minimum of 6 ° of rotation from the operating plane"

24 Modification to 13.11, "Manufacturing of pipe supports"

The heading of the subclause 13.11 shall read as follows:

"13.11 Design and manufacture of pipe supports".

25 Modification to 13.11.2.1, "General"

The first paragraph of 13.11.2.1 shall reads as follows:

"The temperature to be considered in the design of supports shall be related to that of the piping. All support components shall be designed as a minimum for temperatures in the range -20 °C to 80 °C. For ambient or system operating temperatures outside this range, the temperature shall be specified to the pipe support manufacturer."

26 Modification to 13.11.4, "Determination of component sizes"

In 13.11.4.1, the 3rd sentence shall read as follows:

"For further guidance, see Annexes G.4, I, J, K, L and M."

27 Modification to 13.11.4.2, "Stress levels"

Formula (13.11.4.2-2) shall read as follows:

— The maximum permissible stress is:

$$f = \min \left(\frac{R_{eHt}}{1,5} \text{ or } \frac{R_{p0,2t}}{1,5} ; \frac{R_m}{2,4} ; f_{cr} \right) \quad (13.11.4.2-2)$$

with:

$$f_{cr} = S R 200\,000 h t / 1,25$$

NOTE For creep data for time periods other than 200 000 h, see 5.3.2.

28 Modification to 13.11.4.3, "Allowable stress"

The Table 13.11.4.3-1 shall read as follows:

Table 13.11.4.3-1 — Allowable stress for pipe supports

Stress	Normal operating loads	Occasional loads	Faulted condition loads
axial stress σ_a	$< 1,0 f$	$< 1,2 f$	$< 1,5 f$
bending stress σ_b	$< 1,0 f$	$< 1,2 f$	$< 1,5 f$
shear stress τ	$< 0,6 f$	$< 0,7 f$	$< 0,9 f$
equivalent stress σ_e	$< 1,0 f$	$< 1,2 f$	$< 1,5 f$
NOTE 1 The allowable stress for pipe supports not operating in the creep range are: — for pipe supports analysed with plate or shell theory: — normal operating loads: $\sigma_b \leq 1,5 f$; $\sigma_e \leq 1,5 f$ — occasional loads: $\sigma_b \leq 1,8 f$; $\sigma_e \leq 1,8 f$ — faulted condition loads: $\sigma_b \leq 2,25 f$; $\sigma_e \leq 2,25 f$ — two axis bending of double symmetric solid sections: — normal operating loads: $\sigma_b \leq 1,1 f$; $\sigma_e \leq 1,1 f$ — occasional loads: $\sigma_b \leq 1,3 f$; $\sigma_e \leq 1,3 f$ — faulted condition loads: $\sigma_b \leq 1,65 f$; $\sigma_e \leq 1,65 f$ NOTE 2 Allowable stress for welded connection see 13.11.5. NOTE 3 For bolted connections, see 13.11.6. NOTE 4 When the loads are reaching the faulted condition level, the yield stress of components can be reached. In this case replacement is recommended.			

29 Modification to 13.11.5.4, "Fillet welds"

The heading of the Table 13.11.5.4-1 shall read as follows:

Table 13.11.5.4-1 — Allowable stress of a fillet weld

Fillet weld subject to	Normal operating loads	Occasional loads	Faulted condition loads
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30 Modification to 13.11.6.1, "Threaded connections"

The heading of the Table 13.11.6.4-1 shall read as follows:

Table 13.11.6-1— Allowable stress in threaded components

Stress	Normal operating loads	Occasional loads	Faulted condition loads
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31 Modification to 13.11.9, "Design details for shock arrestors (shock absorbers, snubbers)"

The heading of the subclause 13.11.9 shall read as follows:

"13.11.9 Design details for shock arrestors, shock absorbers (snubbers)".

The second paragraph of 13.11.9 shall read as follows:

"Shock arrestors shall be designed to cover the following load spectrum (Table 13.11.9-1). Where F_N is the rated load where the stress level does not exceed the allowable stress given in Table 13.11.4.3-1 for normal operating loads (for further information, see [22] in Bibliography)."

The heading of the Table 13.11.9-1 shall read as follows:

"Table 13.11.9-1 — Load cycle spectrum for shock arrestors, shock absorbers (snubbers)"

32 Modification to Annex H, "Flexibility characteristics, flexibility and stress intensification factors and section moduli of piping components and geometrical discontinuities"

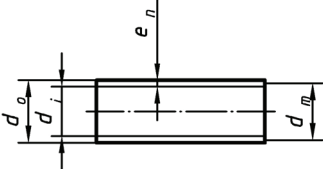
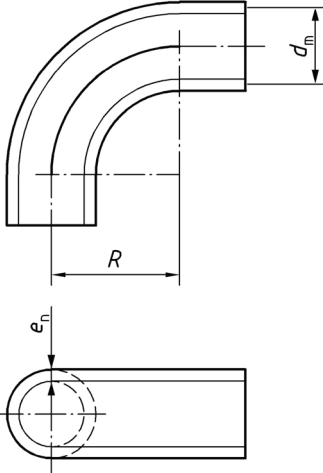
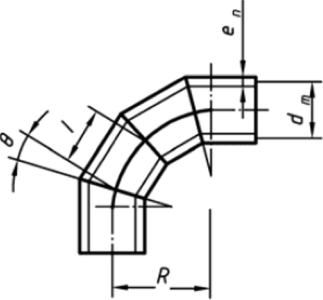
Replace the existing Annex H with the following:

Annex H
(normative)

Flexibility characteristics, flexibility and stress intensification factors and section moduli of
piping components and geometrical discontinuities

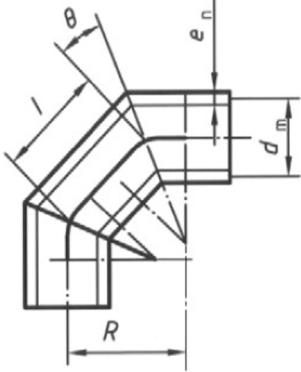
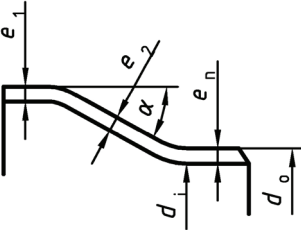
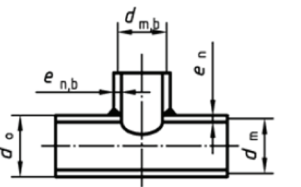
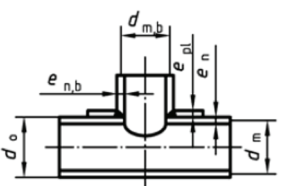
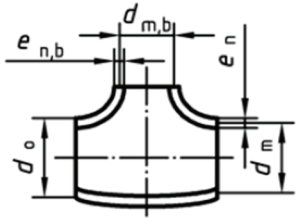
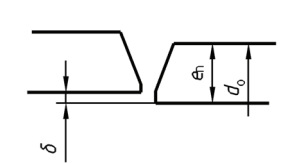
Piping component and geometrical discontinuities characteristics for general cases, particular connections, and out of plane and in plane bending of the piping system shall be in accordance with Tables H.1 to H.3, where $D_o/e_n \leq 100$.

Table H.1 — Flexibility characteristics, flexibility and stress intensification factors and section moduli for general cases

N°	Component designation	Sketch	Flexibility characteristic h	Flexibility factor k_B^a	Stress intensification factor i
1	straight pipe		1	1	1
2	pipe bend		$\frac{4R e_n}{d_m^2}$	$\frac{1,65}{h}$	$\frac{0,9}{h^{2/3}}$ b c h i
3	closely spaced mitre bend $l < d_m (1 + \tan \theta) / 2$ $l = 2 R \tan \theta$		$\frac{4 R e_n}{d_m^2}$ with $R = \frac{l \cot \theta}{2}$	$\frac{1,52}{h^{5/6}}$	$\frac{0,9}{h^{2/3}}$ b c h i

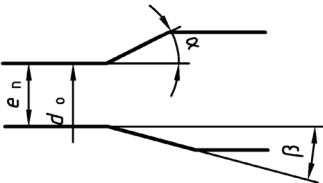
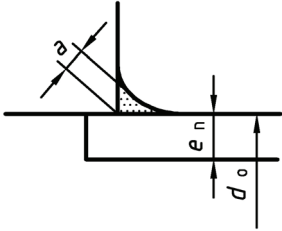
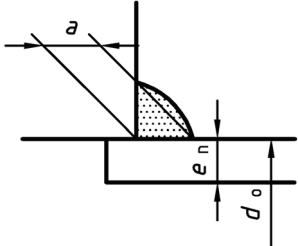
(to be continued)

Table H.1 (continued)

N°	Component designation	Sketch	Flexibility characteristic h	Flexibility factor k_B^a	Stress intensification factor i
4	single mitre bend or widely spaced mitre bend $l \geq d_m (1 + \tan \theta) / 2$		$\frac{4 R e_n}{d_m^2}$ with $R = \frac{d_m (1 + \cot \theta)}{4}$	$\frac{1,52}{h^{5/6}}$	$\frac{0,9}{h^{2/3}}$ b h i
5	forged welded-in reducer		Shape conditions: $\alpha \leq 60^\circ$ $e_n \geq d_o / 100$ $e_2 \geq e_1$	1	$0,5 + \frac{\alpha}{100} \left(\frac{d_o}{e_n} \right)^{1/2}$ max. 2,0 (α in deg.) d
6	tee with welded-on, welded-in or extruded nozzle		$\frac{2e_n}{d_m}$	1	$\frac{0,9}{h^{2/3}}$ b e g j
7	as above, however, with additional reinforcing ring		$\frac{2(e_n + 0,5e_{pl})^{5/2}}{d_m e_n^{3/2}}$ with $e_{pl} \leq e_n$	1	$\frac{0,9}{h^{2/3}}$ b e g j
8	forged welded-in tee with e_n and $e_{n,b}$ as connecting wall thickness		$\frac{8,8e_n}{d_m}$	1	$\frac{0,9}{h^{2/3}}$ b e g j l
9	butt weld		$e_n \geq 5 \text{ mm}$ and $\delta \leq 0,1 e_n$ $e_n < 5 \text{ mm}$ or $\delta > 0,1 e_n$	1 1	$1,0^f$ $1,8^f$

(to be continued)

Table H.1 (concluded)

N°	Component designation	Sketch	Flexibility characteristic h	Flexibility factor k_B^a	Stress intensification factor i
10	wall thickness transitions		$\alpha \leq 30^\circ$ $\beta \leq 15^\circ$ (without circumferential weld at transitions $\delta = 0$)	1	$1,3 + 0,0036 \frac{d_o}{e_n} + 3,6 \frac{\delta}{e_n}$ max 1,9 ^f
11	fillet welds at set-in connections		concave shape with continuous transition to pipe	1	1,3 ^k
12				1	2,1 ^k

^a The flexibility factor k_B applies to bending in all planes. The factor related to torsion is equal to 1 in all cases.

^b The factors k_B and i apply over the whole effective length of the elbows and bends and at the intersection of the axes in case of tees and nozzles.

^c If these components are fitted with:

- flange at one extremity, k_B and i are multiplied by $h^{1/6}$;
- flange at each of the extremities, k_B and i are multiplied by $h^{1/3}$.

^d The wall thickness of the reducer is not less than e_1 except in the vicinity of the small end where however the thickness is not less than e_n .

^e Other values may be used subject to justification.

^f The factor applies if the fabrication tolerances are met. Otherwise the determination of the factors is the responsibility of the designer.

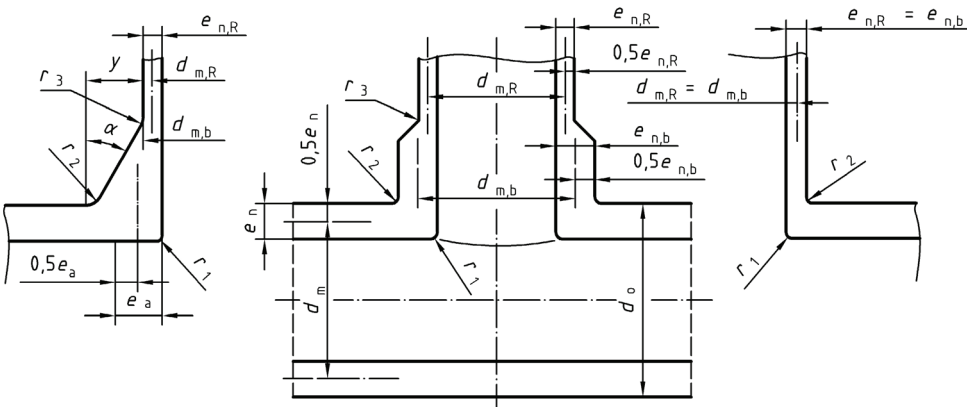
^g The factors only apply to nozzles with convergent axes, not applicable for instance for configurations according to Figure 8.4.3-5.

^h If the pressure is likely to reduce ovality (large diameter, small thickness), the factor i shall be divided by:

$$1 + 3,25 \left(\frac{p_o}{E_c} \right) \left(\frac{d_m}{2e_n} \right)^{5/2} \left(\frac{2R}{d_m} \right)^{2/3}, \text{ where } p_o \text{ is the operating pressure and } E_c \text{ the modulus of elasticity at room temperature (20 } ^\circ\text{C).}$$

N°	Component designation	Sketch	Flexibility characteristic h	Flexibility factor k_B^a	Stress intensification factor i
i	The relevant wall thickness of bends should be taken at the crown (neutral axis). If unspecified, the average wall thickness of intrados and extrados may be used. For elbows, the wall thickness series from EN 10253 may be used. If the pressure is likely to reduce ovality (large diameter, small thickness), the factor k shall be divided by: $1 + 6 \left(\frac{p_o}{E_c} \right) \left(\frac{d_m}{2e_n} \right)^{7/3} \left(\frac{2R}{d_m} \right)^{1/3}, \text{ where } p_o \text{ is the operating pressure and } E_c \text{ the modulus of elasticity at room temperature (20 °C).}$				
j	The sectional modulus for the branch shall be calculated as: $Z = \min \left(i \frac{\pi((d_{m,b} + e_{n,b})^4 - (d_{m,b} - e_{n,b})^4)}{32(d_{m,b} + e_{n,b})}, \frac{\pi}{4} (d_{m,b} + e_{n,b})^2 e_n \right) \text{ or for corrosion}$ $Z_c = \min \left(i \frac{\pi((d_{m,b} + e_{n,b})^4 - (d_{m,b} + e_{n,b} - 2e_{c,b})^4)}{32(d_{m,b} + e_{n,b})}, \frac{\pi}{4} (d_{m,b} + e_{n,b})^2 e_c \right)$				
k	The sectional modulus shall be calculated as: $Z = \min \left(\frac{\pi(d_o^4 - (d_o - 2e_n)^4)}{32d_o}, \frac{\pi}{4} d_o^2 a \right) \text{ or for corrosion}$ $Z_c = \min \left(\frac{\pi(d_o^4 - (d_o - 2e_c)^4)}{32d_o}, \frac{\pi}{4} d_o^2 a \right)$				
l	When the limitations with respect to radius ($r_x \geq d_{m,b} / 8$) and thickness ($e_e \geq 1,5 e_n$) are not met and reliable data are not available, the flexibility characteristic is taken as $h = \frac{6,2 e_n}{d_m}$.				

Table H.2 — Stress intensification factors and section moduli for particular connections

Component designation	Tee with special shape conditions	
Sketch	 $e_{n,b} = e_{n,R} + 2Y/3$$d_{o,b} = d_{m,b} + e_{n,b}$	
shape conditions	$\frac{d_{m,R}}{d_m} \leq 0,5 \quad ; \quad \frac{d_m}{e_n} \leq 100 \quad ; \quad 0,1 e_n \leq r_1 \leq 0,5 e_n$ $r_2 \geq \max \left(\frac{e_{n,b}}{2} ; \frac{e_{n,b} + y}{2} ; \frac{e_n}{2} \right) \quad \alpha \leq 30^\circ$ $r_3 \geq \max \left\{ \alpha \frac{d_{m,R} + e_{n,R}}{500} ; \sin^3 \alpha (d_{m,b} + e_{n,b} - d_{m,R} - e_{n,R}) \right\}$ For the conditions of r_3 α shall be in deg. For branches DN < 100 the conditions for r_1 can be omitted.	
stress intensification factors	for header: If r_2 is known and respects the shape conditions: $i = 0,4 \left(\frac{d_m}{2e_n} \right)^{\frac{2}{3}} \frac{d_{m,R}}{d_m}$ but at least $i = 1,5$. If r_2 is unknown or do not respect the shape conditions: $i = 0,8 \left(\frac{d_m}{2e_n} \right)^{\frac{2}{3}} \frac{d_{m,R}}{d_m}$ but at least $i = 2,1$.	for branch: $i = 1,5 \left(\frac{d_m}{2e_n} \right)^{\frac{2}{3}} \left(\frac{d_{m,R}}{d_m} \right)^{\frac{1}{2}} \frac{e_{n,R}}{e_n} \frac{d_{m,R}}{d_{m,b} + e_{n,b}}$ but at least $i = 1,5$

(to be continued)

Table H.2 (continued)

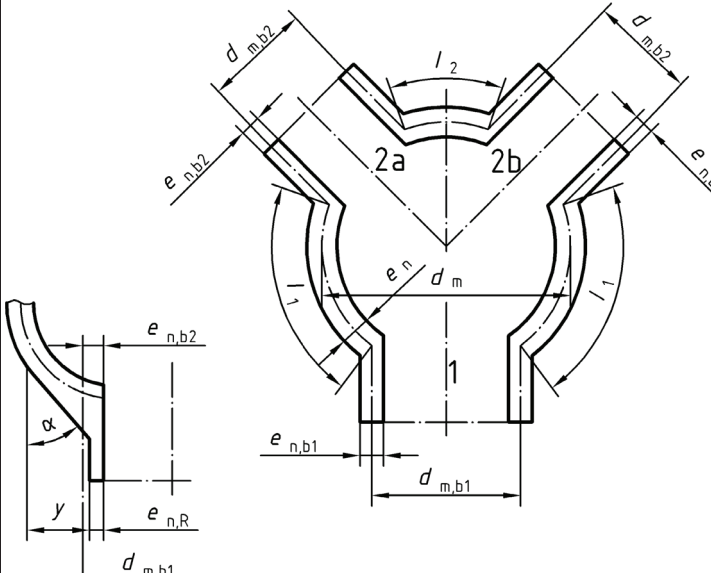
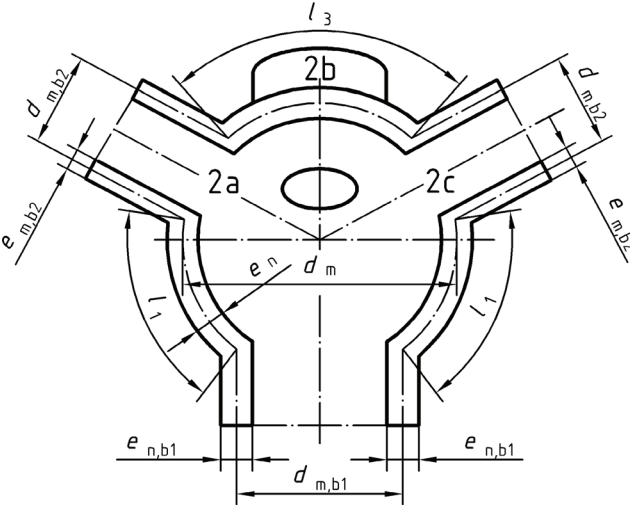
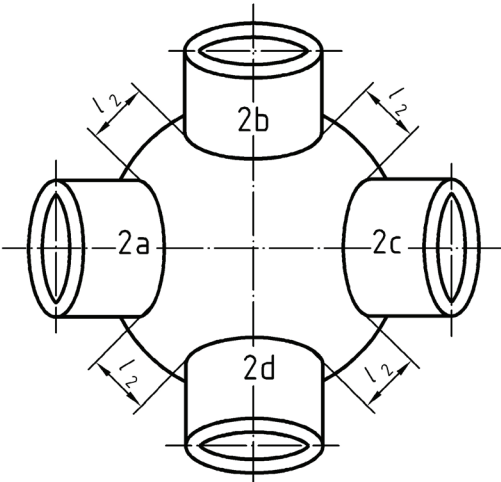
Component designation	Y-spherical fitting		
sketch			
	$e_{n,b1} = e_{n,R} + 2y/3$ $d_o = d_m + e_n$ $d_{o,b1} = d_{m,b1} + e_{n,b1}$ $d_{o,b2} = d_{m,b2} + e_{n,b2}$		
factors of influence $l_o, \lambda_1, \lambda_2$	$l_o = 2\sqrt{d_m e_n} \quad ; \quad \lambda_1 = 1 - \sqrt{\frac{l_1}{l_o}} \quad ; \quad \lambda_2 = 1 - \sqrt{\frac{l_2}{l_o}}$ for $l_1 \geq l_o, \lambda_1 = 0$ and for $l_2 \geq l_o, \lambda_2 = 0$		
Flexibility characteristic h	$h = \frac{2 e_n}{d_m}$	stress intensification factor i	$i = \frac{0,9}{h^{2/3}}$
Sectional modulus	$Z = \min \left(i \frac{\pi((d_{m,b} + e_{n,b})^4 - (d_{m,b} - e_{n,b})^4)}{32(d_{m,b} + e_{n,b})}, \frac{\pi}{4} (d_{m,b} + e_{n,b})^2 e_n \right)$ or for corrosion $Z_c = \min \left(i \frac{\pi((d_{m,b} + e_{n,b})^4 - (d_{m,b} + e_{n,b} - 2e_{c,b})^4)}{32(d_{m,b} + e_{n,b})}, \frac{\pi}{4} (d_{m,b} + e_{n,b})^2 e_c \right)$		
	Nozzle 1	Nozzle 2a	Nozzle 2b
substitute values for the terms $\frac{M_A}{Z} \quad \frac{M_B}{Z}$ $\frac{M_C}{Z} \quad \frac{M_D}{Z}$	$\frac{M_1}{Z_1} + \frac{\lambda_1 M_{2a}}{Z_2}$ $\frac{M_1}{Z_1} + \frac{\lambda_1 M_{2b}}{Z_2}$	$\frac{M_{2a}}{Z_2} + \frac{\lambda_1 M_1}{Z_1}$ $\frac{M_{2a} + \lambda_2 M_{2b}}{Z_2}$	$\frac{M_{2b}}{Z_2} + \frac{\lambda_1 M_1}{Z_1}$ $\frac{M_{2b} + \lambda_2 M_{2a}}{Z_2}$
in equations given in 12.3.2 to 12.3.6	The greater value obtained from the two formulas shall be inserted in equations given in 12.3.2 to 12.3.6 for the respective branches instead of M/Z. Then the following applies: $M_1 = M_{A,B,C,D}$ at nozzle 1, $M_{2A} = M_{A,B,C,D}$ at nozzle 2a and $M_{2B} = M_{A,B,C,D}$ at nozzle 2b.		
	(to be continued)		

Table H.2 (continued)

Component designation	Double Y-spherical fitting		
sketch			
factors of influence $l_o, \lambda_1, \lambda_2, \lambda_3$	$l_o = 2\sqrt{d_m e_n}$ $\lambda_1 = 1 - \sqrt{\frac{l_1}{l_o}}$ $\lambda_2 = 1 - \sqrt{\frac{l_2}{l_o}}$ $\lambda_3 = 1 - \sqrt{\frac{l_3}{l_o}}$ if $l_{1,2,3} \geq l_o$, then $\lambda_{1,2,3} = 0$		
Flexibility characteristic h	$h = \frac{2 e_n}{d_m}$		
stress intensification factor i	 $i = \frac{0,9}{h^{2/3}}$		
Sectional modulus	$Z = \min \left(i \frac{\pi((d_{m,b} + e_{n,b})^4 - (d_{m,b} - e_{n,b})^4)}{32(d_{m,b} + e_{n,b})}, \frac{\pi}{4}(d_{m,b} + e_{n,b})^2 e_n \right) \text{ or for corrosion}$ $Z_c = \min \left(i \frac{\pi((d_{m,b} + e_{n,b})^4 - (d_{m,b} + e_{n,b} - 2e_{c,b})^4)}{32(d_{m,b} + e_{n,b})}, \frac{\pi}{4}(d_{m,b} + e_{n,b})^2 e_c \right)$		
substitute values for the	Nozzle 1	Nozzle 2a	Nozzle 2b, c, d

Component designation	Double Y-spherical fitting		
terms $\frac{M_A}{Z}$$\frac{M_B}{Z}$ $\frac{M_C}{Z}$$\frac{M_D}{Z}$ in equations given in 12.3.2 to 12.3.6	$\frac{M_1}{Z_1} + \frac{\lambda_1 M_{2a}}{Z_2}$ $\frac{M_1}{Z_1} + \frac{\lambda_1 M_{2b}}{Z_2}$ $\frac{M_1}{Z_1} + \frac{\lambda_1 M_{2c}}{Z_2}$ $\frac{M_1}{Z_1} + \frac{\lambda_1 M_{2d}}{Z_2}$	$\frac{M_{2a}}{Z_2} + \frac{\lambda_1 M_1}{Z_1}$ $\frac{M_{2a} + \lambda_2 M_{2b}}{Z_2}$ $\frac{M_{2a} + \lambda_3 M_{2c}}{Z_2}$ $\frac{M_{2a} + \lambda_2 M_{2d}}{Z_2}$	$M_{2a} \cong M_{2b,c,d}$ $M_{2b} \cong M_{2c,d,a}$ $M_{2a} \cong M_{2d,a,b}$ $M_{2a} \cong M_{2a,b,c}$

Table H.3 — Flexibility characteristics and stress intensification factors for out-of-plane and in-plane bending

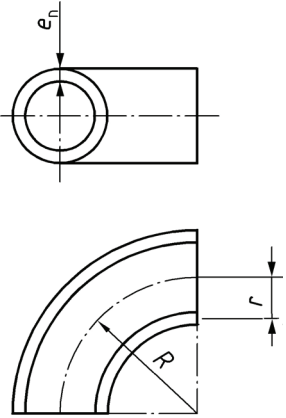
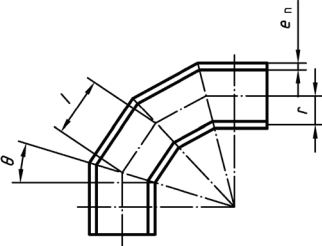
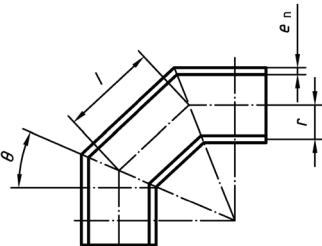
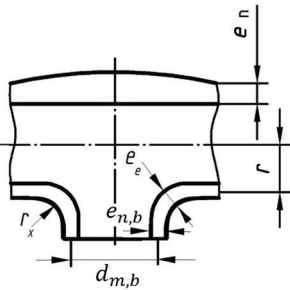
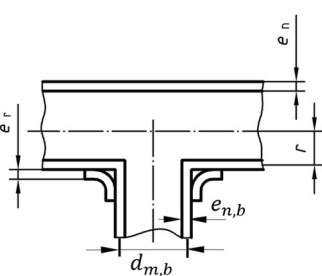
N°	Component designation	Sketch	Flexibility characteristic h	Stress intensification factor	
				Out-of-plane i_o	In-plane I_i
1	Welding elbow or pipe bend		$\frac{e_n R}{r^2}$	$\frac{0,75}{h^{2/3}}$ a b c j	$\frac{0,9}{h^{2/3}}$ a b c j
2	Closely spaced mitre bend $l < r (1 + \tan \theta)$ ($l = 2 R \tan \theta$)		$\frac{\cot \theta}{2} \frac{e_n l}{r^2}$	$\frac{0,9}{h^{2/3}}$ a b c j	$\frac{0,9}{h^{2/3}}$ a b c j
3	Single mitre bend or widely spaced mitre bend $l \geq r (1 + \tan \theta)$		$\frac{e_n}{r} \left(\frac{1 + \cot \theta}{2} \right)$	$\frac{0,9}{h^{2/3}}$ a b c j	$\frac{0,9}{h^{2/3}}$ a b c j
4	Forged tee to be welded, designed with a burst pressure greater than or equal to the burst pressure of the connected pipes		$\frac{4,4 e_n}{r}$	$\frac{0,9}{h^{2/3}}$ a e f g i k	$0,75 i_o + 0,25$ a e f g i k
5	Reinforced fabricated tee with pad or saddle		$\frac{(e_n + 0,5 e_r)^{5/2}}{r (e_n^{3/2})}$	$\frac{0,9}{h^{2/3}}$ a d e i k	$0,75 i_o + 0,25$ a d e i k

Table H.3 (continued)

N°	Component designation	Sketch	Flexibility characteristic h	Stress intensification factor	
				Out-of-plane I_o	In-plane i_i
6	Unreinforced fabricated tee		$\frac{e_n}{r}$	$\frac{0,9}{h^{2/3}}$ adeik	$0,75 i_o + 0,25$ adeik
7	Extruded welding tee		$\left(1 + \frac{r_1}{r}\right) \frac{e_n}{r}$	$\frac{0,9}{h^{2/3}}$ aeik	$0,75 i_o + 0,25$ aeik
8	Welded in contour insert		$\frac{4,4e_n}{r}$	$\frac{0,9}{h^{2/3}}$ aefgik	$0,75 i_o + 0,25$ aefgik
9	Branch welded on fitting (integrally reinforced)		$\frac{3,3e_n}{r}$	$\frac{0,9}{h^{2/3}}$ adfhk	$\frac{0,9}{h^{2/3}}$ adfhk
(to be continued)					

Table H.3 (concluded)

a	The factors i_o and i_i apply over the whole effective length of the elbows and bends and at the intersection of the axes in case of tees and nozzles.
b	If these components are fitted with: - flange at one extremity, i_o and i_i are multiplied by $h^{1/6}$; - flange at each of the extremities, i_o and i_i are multiplied by $h^{1/3}$.
c	If the pressure is likely to correct ovality (large diameter, small thickness), the factors i_o and i_i shall be divided by: $1 + 3,25 \left(\frac{p_o}{E_c} \right) \left(\frac{r}{e_n} \right)^{5/2} \left(\frac{R}{r} \right)^{2/3}$, where p_o is the operating pressure and E_c the modulus of elasticity at room temperature (20°C).
d	For a nozzle with a ratio of branch diameter to pipe diameter exceeding 0,5, the out-of-plane stress intensification factor may be non-conservative. In addition a smooth transition by a concave shaped weld is proved to reduce the value of this factor. Consequently the selection of an appropriate value for this factor remains the responsibility of the designer.
e	The stress intensification factors regarding the branch connections are based on tests carried out with at least two diameters of straight pipe on either side of the branch axis. The case of closer branches requires a particular attention.
f	The forgings shall be suitable with regard to the operating conditions.
g	When the limitations with respect to radius ($r_x \geq r_{mb}/4$) and thickness ($e_e \geq 1,5 e_n$) are not met and reliable data are not available, the flexibility characteristic is taken as $h = \frac{3,1 e_n}{r}$.
h	The designer shall check that the design against pressure is at least equivalent to that for a straight pipe.
i	The factors only apply to nozzles with convergent axes, and is not applicable for instance for configurations according to Figure 8.4.3-5.
j	The relevant wall thickness of bends should be taken at the crown (neutral axis). If unspecified, the average wall thickness of intrados and extrados may be used. For elbows, the wall thickness series from EN 10253 may be used. If the pressure is likely to reduce ovality (large diameter, small thickness), the factor k shall be divided by: $1 + 6 \left(\frac{p_o}{E_c} \right) \left(\frac{r}{e_n} \right)^{7/3} \left(\frac{R}{r} \right)^{1/3}$, where p_o is the operating pressure and E_c the modulus of elasticity at room temperature (20°C).
k	The sectional modulus for the branch shall be calculated as: $Z = \min \left(i \frac{\pi((d_{m,b} + e_{n,b})^4 - (d_{m,b} - e_{n,b})^4)}{32(d_{m,b} + e_{n,b})}, \frac{\pi}{4}(d_{m,b} + e_{n,b})^2 e_n \right)$ or for corrosion $Z_c = \min \left(i \frac{\pi((d_{m,b} + e_{n,b})^4 - (d_{m,b} + e_{n,b} - 2e_{c,b})^4)}{32(d_{m,b} + e_{n,b})}, \frac{\pi}{4}(d_{m,b} + e_{n,b})^2 e_c \right)$

33 Modification to Annex J, "Type testing of support components"

In J.1, the 3rd sentence shall read as follows:

"Testing shall be carried out at room temperature, but to compensate for operation at elevated temperature, the load derived under test conditions shall be multiplied by the reducing factor $R_{eH,t} / R_{eH,RT}$ or $R_{p0,2,t} / R_{p0,2,RT}$, where RT is the room temperature during testing, and t the design temperature of the support under test."

In Table J.4-1, in the footnote, the formula for K_2 shall read as follows:

$$K_2 = \frac{R_{p0,2,\text{tension test}}}{R_{p0,2,\text{material specification}}} \text{ or } K_2 = \frac{R_{eH,\text{tension test}}}{R_{eH,\text{material specification}}}$$

English Version

Metallic industrial piping - Part 3: Design and calculation

Tuyauteries industrielles métalliques - Partie 3 :
Conception et calcul

Metallische industrielle Rohrleitungen - Teil 3:
Konstruktion und Berechnung

This amendment A3 modifies the European Standard EN 13480-3:2017; it was approved by CEN on 12 July 2020.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for inclusion of this amendment into the relevant national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This amendment exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

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European foreword

This document (EN 13480-3:2017/A3:2020) has been prepared by Technical Committee CEN/TC 267 “Industrial piping and pipelines”, the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 2021, and conflicting national standards shall be withdrawn at the latest by February 2021.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a standardization request given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this EN 13480-3:2017.

This document includes the text of the amendment itself. The amended/corrected pages of EN 13480-3:2017 will be published as Issue 4 of the European Standard.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Modification to Clause 2, "*Normative references*"

Add the following normative reference:

"EN 12516-2:2014, *Industrial valves — Shell design strength — Part 2: Calculation method for steel valve shells*".

2 Modification to 5.2.4, "*Steel castings*"

Clause 5.2.4 shall read as follows:

"5.2.4 Steel castings

For steel castings, allowable stresses are specified in EN 12516-2:2014."

3 Modification to Annex A, "*Dynamic effect*"

Replace the existing Annex A with the following:

Annex A (informative)

Dynamic effect

A.1 General

A.1.1 Introduction

In addition to the static conditions and cyclic pressure and temperature loadings covered by 4.2, piping may be subjected to a variety of dynamic loadings. Dynamic events should be considered in the design of the piping. However, unless otherwise specified, such consideration may not require detailed analysis. The effects of significant dynamic loads should be added to the sustained stresses in the design of the piping. Continuous dynamic loads should be considered in a fatigue analysis.

Analysis methods are proposed in A.2.

However vibration may be more difficult to predict and recommendations for installations are also provided in a design guidelines A.1.2.

A vibration risk assessment may be performed, based on the combined knowledge of vibration sources and the dynamic properties of the piping system (A.2.7).

The piping system dynamic properties may also be used to judge the dynamic quality of the layout, to locate vibration measures and damages.

A.1.2 Vibration design guidelines

A.1.2.1 General

The following guideline may be used to get a reduction in the number of pipework circuits that exceed vibratory acceptance criteria.

Three aspects are faced to optimize the vibrational behaviour of the piping system:

- the definition of the operation of circuits;
- the recommendation for pumps, valves, and orifice plates;
- the installation of piping and their supports.

A.1.2.2 Operation of the circuit

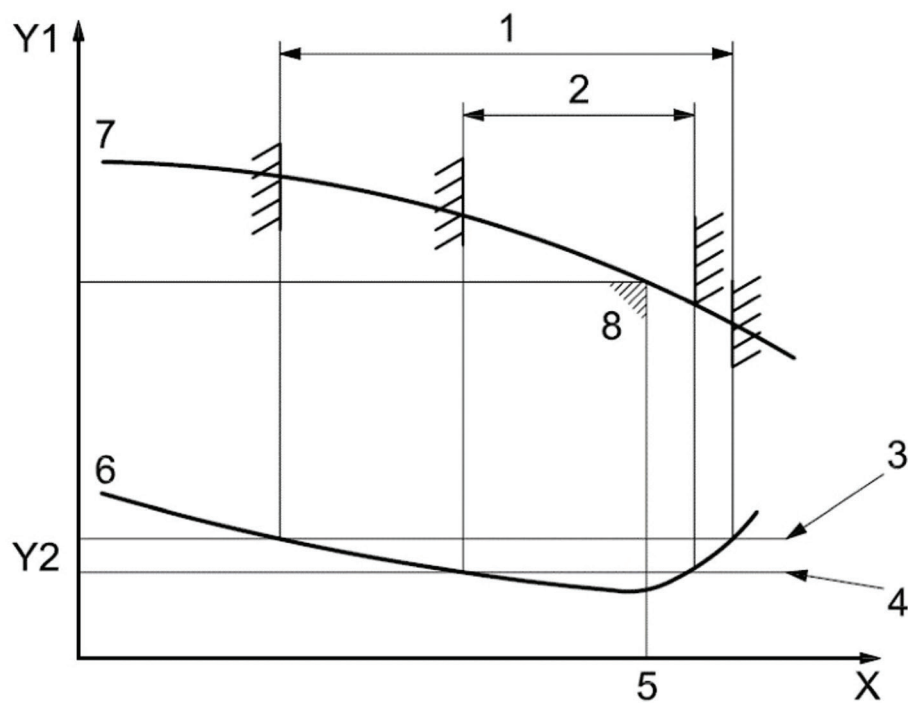
A.1.2.2.1 Functional analysis

To minimize the potential crack initiation on small bore pipe connections to large pipes or valves, it is essential to conduct a complete functional analysis of the system. This should include, in particular, the periodic testing and condition monitoring during operation and the ambient environment in extreme conditions. This procedure applies even if the operating times in some configurations are low (of the order of a few minutes per cycle).

The adequacy of the equipment and the installation for every operational modification should be assessed.

A.1.2.2.2 Partial flow or overflow operation

The operation of pumps with partial flow or overflow leads to significant flow fluctuations. Partial flow or overflow refers to an operation of the pumps outside of the field of maximum efficiency (areas 1 and 2 of Figure A.1.1.1-1), in theory close to the nominal value (point 8 of Figure A.1.1.1-1), and leading to a high fluid excitation source (curve 6 of Figure A.1.1.1-1) compared with the nominal value.



Key

- | | |
|--|--|
| X flowrate | 4 basic vibration limit |
| Y1 head | 5 best efficiency point, flowrate |
| Y2 vibration | 6 typical vibration vs. flowrate curve showing maximum allowable vibration |
| 1 allowable operating region of flow | 7 head-flowrate curve |
| 2 preferred operating region of flow | 8 best efficiency point, head and flowrate |
| 3 maximum allowable vibration limit at flow limits | |

Figure A.1.1.1-1 — Relationship between flow and vibration

The operation of pumps with partial flow or overflow should be avoided. The periodic testing should be positioned where possible in the operating conditions that are least damaging from a vibratory stand point. When these configurations cannot be achieved, the operating times should be limited.

Pump by-passes (feedback of the discharge to the vacuum or to the tank) fitted with ahead loss unit may be implemented, but should ensure that regulation of the flow during discharge remains close to the nominal value. In this case, particular care should be taken to ensure that the vibratory design of these by-pass lines comply with the rules for valves and installation.

Size the zero flow rate lines used in the context of the pump periodic testing to be on an operating level close to the nominal value in accordance with the periodic testing rules.

The pump should have a flow rate above 70 % and below 110 % of the nominal flow rate of the pump.

If the equipment is known, the partial flow rate may possibly be defined by the manufacturer.

A.1.2.2.3 Cavitation

Cavitation is known to lead to excessive vibrations in the pipework circuits (cavitation of orifice plates, cavitation of butterfly valves and vacuum orifice plates under vacuum conditions).

It is important to note that in cavitation conditions, the operating conditions cannot be ranked. The experience feedback from vacuum conditions or from the operation of plants, does indeed show that changes in vibratory levels are not correlated with the increase or decrease in cavitation indexes from the literature

Cavitation should be prevented or at least limited. This rule is generally complied with through the choice of equipment (A.1.2.3). However, it is absolutely necessary for the operation managers to provide the consultants with the worst case head losses and flow rates. To this end, it should take into account all the operating configurations (normal, disturbed, occasional, accidental, periodic testing) in accordance with A.1.2.2.1.

The Installation Rules for water hammer recommendations concerning the cavitation should be applied.

A.1.2.2.4 Connected small bore pipes

The reduction in the number of connected small bore pipes leads directly to the reduction of the risk of cracking by vibratory fatigue, thus the number of functional connected small bore pipes should be minimized.

Slope reversals should be reduced so as to minimize the number of connected small bore pipes for drains and vents.

A.1.2.2.5 Flow velocity

The following flow velocity values are recommended.

For liquids:

- Normal velocity < 3 m/s
- Exceptional velocity or pressure greater than 50 bar < 5 m/s

For air and gases:

- Flow velocity < 40 m/s

For steam as function of specific volume:

- 0,02 m³/kg: 35 – 45 m/s
- 0,05 m³/kg: 40 – 50 m/s
- 0,1 m³/kg: 45 – 55 m/s
- 0,2 m³/kg: 50 – 60 m/s

A.1.2.3 Equipment

A.1.2.3.1 Pumps and compressors

The cracking of connected small bore pipes may be due to excessive vibrations of such components. The damage from these vibrations is amplified when they coincide with the vibratory modes of the piping.

The vibratory design rules of pumping/compression systems, should be taken into account, in particular the non-concurrence of frequency between the pump/compressor peaks and the vibratory modes of pump/compressor-header assemblies.

The excitation frequencies, resulting from pump speed and number of blades (for centrifugal pumps), should be checked for their effect on the piping system by determining the natural frequencies or by means of harmonic excitation.

Piston pumps and compressors cause strong pressure pulses inducing high vibrations. The experience feedback shows that post installation, it is very difficult to limit the vibrations of headers and connected small bore pipes induced by this type of component.

In general, the use of piston pumps/compressors should be avoided.

However, if strong functional requirements impose the use of this type of component, validated pulsation dampers or acoustical filters should be proposed by the manufacturer.

In general, adding head losses in a circuit is equivalent to increasing the level of vibratory sources, reducing efficiency and therefore increasing operating cost.

The use of orifice plates in order to adjust the pump characteristics for the pipework circuit head losses is not recommended. However, for some pipework circuits, the opening of valves may be limited in order to prevent the operation of pumps outside their normal range.

Furthermore, the impeller diameter reduction automatically leads to a reduction in pump performance and an increase in the corresponding hydro acoustic source.

It is recommended to avoid where possible the use of oversized pumps leading to the pointless addition of head losses in the pipework circuit.

The characteristics of pumps (flow rate, pressure) should be specified based on a functional analysis of the system.

The specifications of pump characteristics (flow rate, pressure) should be estimated as accurately as possible based on the characteristics of the pipework circuit and operating conditions.

A.1.2.3.2 Valves

Experience shows that cavitation in control valves, in particular butterfly valves leads to high vibratory levels in the pipework circuits. The switch to cavitation conditions leads to a sudden increase of these levels.

Cavitation should be prevented on control valves, especially for butterfly valves.

For other valves, excluding control valves, there is no indication of cavitation leading to high levels of vibration. It is nevertheless preferable to limit the risk of cavitation on the other types of valves.

The limitation of cavitation and associated criteria are the responsibility of valve Manufacturers, in accordance with the application of current standards.

A.1.2.3.3 Orifice Plates

Single hole orifice plates present risks of air 'whistling' at a higher frequency, between vortex release at the orifice and an acoustic cavity of the piping. Outside of a possible acoustic discomfort, this air 'whistling' can present a fairly high energy vibratory source that may lead to damage.

The frequency of vortex release is characterized by the Strouhal number:

$$S_r = \frac{f t}{V}$$

Where:

S_r depends on the studied geometry and remains in the region of 0,2 for a mono-hole orifice plate of ratio $t/D_{\text{hole}} < 1$,

f is the frequency of vortices,

t is the thickness of the diaphragm

V is the flow velocity in the orifice.

D_{hole} is the elementary diameter of the orifice plate hole(s)

For a plate with N holes:

$$S_r = \frac{\pi D_{\text{hole}}^2 N f t}{4Q}$$

Where:

Q is the flowrate

The example of system single and multi-hole orifice plates with identical head loss coefficients shows that the increase in the number of holes has little impact on the frequency of vortex release at $Q = 30 \text{ m}^3/\text{s}$ with $S_r = 0,2$

— Orifice plate single-hole $N = 1$, $D_{\text{hole}} = 22,3 \text{ mm}$ $f = 304 \text{ Hz}$;

— Orifice plate multi-holes $N = 47$, $D_{\text{hole}} = 3 \text{ mm}$, $f = 358 \text{ Hz}$.

However, the multi-hole orifice plate does not make any air 'whistling'. This observation can be explained by the ratio $t/D_{\text{hole}} > 1$ which leads to $S_r > 0,2$.

The multi-hole plates also enable the level of turbulence to be reduced by reducing the scale of vortices and decorrelating them.

However, the use of multi-hole plates only enables a moderate reduction of cavitation and its vibratory effects.

Orifice plates such as single-hole plates should be prohibited except for flow rate measurement orifice plates. It is recommended to implement multi-hole plates, maximizing the number of holes with a minimum diameter of a few millimetres, but not so small that flow is blocked by particles in the flow. Purging and filters can be applied to avoid this.

Many single-stage orifice plates in plants are cavitating. The multistage technology is widely used in plants and the sizing methods of valve Manufacturers have been validated.

The use of orifice plates with several plates in series enables head losses to be distributed while maintaining pressures downstream of every plate sufficiently high not to cause cavitation. The critical plate is generally the last as it should withstand a low headloss and its critical Tullis number is the lowest.

The flow rate orifice plates generally have low head losses which explains why cavitation experience feedback from this type of component is reduced or even non-existent. The sizing should still be checked if they do not cavitate. If they cavitate, two solutions exist. Either reduce their head loss, or increase their

downstream pressure (p_2) by moving them in the pipework circuit. Furthermore, the validity of the flow rate measurement taken at the terminals of a cavitating orifice plate can be questioned.

It is recommended to size the orifice plates taking account of the risk of cavitation. Implement multi-stage multi-hole orifice plates to prevent this risk, except for flow rate measurement orifice plates.

For flow rate measurement orifice plates, reduce their head loss coefficient and place them if possible in a zone of the pipework circuit where the pressures are the highest.

For flow rate measurement orifice plates (single hole), the Thoma number σ – defined as follows, should be greater than or equal to 5.

By stating:

p_1 is upstream pressure

p_2 is downstream pressure

Δp is $p_2 - p_1$

p_v is liquid steam pressure at the service temperature

For the worst case conditions, the Thoma number should comply with:

$$\sigma = \frac{p_2 - p_v}{\Delta p} \geq 5$$

For multi-hole orifice plates, the sizing rules established and validated by valve Manufacturers should be applied. If the worst case operating conditions do not enable the use of multi-hole single stage plates, the implementation of multi-hole multi-stage orifice plates should be considered.

A.1.2.4 Layout

A.1.2.4.1 Main piping (headers)

From experience and the seismic requirements, concentrated masses (e.g. valves, pulsation dampers) should be as close as possible to supports.

High power pumps induce much energy, it is recommended for pipework circuits with pumping systems that have a power ($Q \times \text{TDH}$) greater than 500 kW, to perform a vibratory design review in order to limit the risks of excessive vibrations before start-up.

— Q is flowrate (m^3/s)

— TDH is Total Dynamic Head (kPa)

It is recommended to limit the 'vibratory bridges' between pipe lines supports. If this is not possible, the rigidity of the common supports should be increased.

It is recommended to have supports positioned a maximum of three bends upstream or downstream of a potential vibration source (e.g. a partial flow pump). The supports referred to here are those without clearance.

The downstream turbulence of a valve or orifice plate may propagate itself downstream in the piping. This rule enables the direct excitation of the pipework circuit by the turbulence to be limited. Independent of vibratory problems, it is recommended to ensure that the straight lengths upstream and downstream of pressure dropping features are adequate.

To limit vibration problems, a minimum distance of 5 DN (nominal diameter), recommended 7 DN, should be maintained between the isolated head loss component and the first downstream bend or change in direction.

A.2 Analysis by calculation

A.2.1 General

The main different methods for the calculation of the effect of dynamic events, are:

- a) simplified static equivalent;
- b) quasi-static equivalent;
- c) modal response spectra analysis;
- d) force time history.

Experience has shown that for properly supported piping, the use of simplified methods generally leads to acceptable engineering solutions for the prevention of damage during dynamic events. Where complex analysis is to be undertaken, care should be exercised in the selection of suitable programs and consistent data for the derivation of forces and allowable loads.

Piping and piping components may also be verified by subjecting full or part scale models to a vibratory regime comparable to the expected dynamic loading.

A.2.2 Seismic events

A.2.2.1 General

Seismic events produce vibratory ground movements which are transmitted through the building structure to piping and other equipment. The structure and equipment respond by undergoing accelerations and displacements whose magnitude varies with their stiffness and natural resonance frequencies.

The analysis of the interaction of the building structure with the seismic driving forces is not within the scope of piping design and the associated response will normally be supplied by the purchaser or site owner, following earthquake assessment and structural analysis of the proposed building.

An analysis of the piping should be carried out to show the maximum forces and moments generated within the piping as a result of the structures response to the predicted earthquake; combining those forces whose direction makes them additive to the static loads. However, care should be taken regarding the displacements as both plus and minus movements may be needed for layout and supporting detail design.

The type of calculation determines the form and extent of seismic data to be made available to the piping designer.

A.2.2.2 Simplified static equivalent analysis

This method ignores the variation in the structure's response at different frequencies and damping rates, and calculates the displacements and forces in the piping using a single equivalent static accelerating force for each principal direction of seismic movements. This acceleration is based upon the maximum value arising from the earthquake. It may be presented to the designer as a ground base response spectrum, or calculated for each level within the building structure, or given as a single set of responses which are considered to envelope the different responses applicable to the piping.

Where no building related accelerations are available, the designer should use the peak ground acceleration as the maximum acceleration a_i .

The static equivalent acceleration, a_{cqi} , for direction i is calculated as follows:

$$a_{cqi} = k_i a_i \tag{A.2.1-1}$$

Where:

- a_i is the maximum acceleration defined for the level in direction i ;
- k_i is a factor;
 - $k_i = 1$ where the natural frequencies of the piping can be shown not to coincide within 10 % of the peak vibration frequencies in the response spectrum of the structure;
 - $k_i = 1,5$ where no check on the coincidence of piping and building vibration characteristics has been undertaken.

A.2.2.3 Quasi-static equivalent analysis

This calculation applies a single static acceleration for each of the directions of the ground vibration equivalent to the highest acceleration in the building response spectrum which can excite the piping. For this method, the significant natural frequencies of the piping should be calculated.

The quasi-static equivalent acceleration $a_{qe i}$ for direction i is calculated as follows:

$$a_{qe i} = \bar{k}_i a_{fi} \tag{A.2.1-2}$$

Where:

- a_{fi} is the maximum acceleration in the ground or level vibration spectrum at frequencies greater than or equal to the first own frequency of the piping;
- $\bar{k}_i$ is a factor related to the contributions of multiple own frequencies for the shape of the piping system.

The factor $\bar{k}_i$ should be determined from Table A.2.1-1. Lower values of the factor may be used where their admissibility is demonstrated.

Table A.2.1-1 — Values of $\bar{k}_i$

Model	$\bar{k}_i$
Multi supported linear beam with equal span lengths	1,0
Cantilever beam	1,0
Single beam supported at both ends (maximum forces are to be applied at every cross section)	1,0
Single plane systems, e.g. frames, girder systems, single plane piping	1,2
3 dimensional systems with complex shapes	1,5

For rigid piping (i.e. where the lowest own frequency of the system is higher than or equal to the cut-off frequency of the ground vibration spectrum) the value of $\bar{k}_i$ may be taken as 1,0.

For the determination of support reactions, the value of $\bar{k}_i$ may be taken as 1,0 irrespective of which model is used from Table A.2.1-1.

A.2.2.4 Modal response spectra analysis

A.2.2.4.1 General

For modal response spectra analysis, the piping designer requires a building response spectrum for each level/location within the structure, or a spectrum which can be considered to envelope the responses within the structure. This modal response spectrum is derived from the maximum accelerations generated by the earthquake at differing frequencies over an appropriate period of time, and their interaction with the building structure. Vibration analysis of the piping should be carried out to determine the displacements, moments, and forces for the imposed accelerations at each significant frequency in the modal spectrum.

A.2.2.4.2 Modal combination

The total response of the piping (displacements, moments, forces) for each direction should be obtained by combining each peak modal response using a suitable superposition method:

Absolute sum superposition (ABS):

$$R_i = \pm \sum_{j=1}^n |R_{ji}| \quad (\text{A.2.1-3})$$

Square root of the sum of the squares (SRSS):

$$R_i = \pm \sqrt{\sum_{j=1}^n R_{ji}^2} \quad (\text{A.2.1-3})$$

Complete quadratic combination (CQC):

$$R_i = \pm \sqrt{\sum_{j=1}^n \sum_{k=1}^n R_{ji} \rho_{jk} R_{ki}}$$

where:

$$\rho_{ij} = \frac{8\zeta^2 (1+r)r^{3/2}}{(1-r^2)^2 + 4\zeta^2 r(1+r)^2},$$

$$r = \frac{\omega_j}{\omega_i}, \quad \zeta : \text{Damping} \quad (\text{A.2.1-4})$$

Maximum value superposition (MAX):

$$R_i = \pm \max_{j=1}^n |R_{ji}| \quad (\text{A.2.1-5})$$

Where:

R_i is the total response in the principal direction i ;

R_{ji} is the peak response due to mode j in the principal direction i ;

n is the number of significant modes.

Absolute combination can always be used but may be over-conservative in many situations. If the response components can be considered statistically non-correlated the SRSS method can be used. For situations with many close modes (with similar frequency) the CQC method is most suitable. The MAX superposition should only be used in cases where simultaneous action of the components is very improbable and interactions can be neglected.

A.2.2.4.3 Missing-Mass

In order to take into account the residual mass, not participating in the mode shapes calculated up to a given frequency limit during the analysis, the remaining mass should be accelerated using a static acceleration corresponding to the maximum value of the response spectrum above the frequency limit (highest calculated eigenfrequency). This result is called “residual mode” and should be combined with the modal response using a suitable superposition method (typically SRSS).

A.2.2.4.4 Building Contributions

If the piping system is attached to different buildings which perform independent movements during a seismic event, the contribution of each building and each direction should be calculated separately. These building contributions should be combined with the modal response using a suitable superposition method (typically SRSS).

A.2.2.4.5 Spatial combination

The three spatial directions should be combined with the modal response using a suitable superposition method.

For most piping systems the combination of piping responses from the three principal directions can be based on the following assumptions:

- the piping responses to different building modal peaks do not occur at the same time;
- peak responses do not occur simultaneously in the three principal directions;

Consequently the maximum response of the system may be calculated by applying the MAX or SRSS method to the three orthogonal directional maxima.

A.2.2.5 Force time history analysis

Where seismic displacements of the supporting structure are known with respect to time, the dynamic response of the piping system can be determined. This is done by imposing the pattern of accelerations or displacements at the support and terminal point locations onto a suitable model of the piping which incorporates the stiffness and masses of the piping and appropriate dynamic damping factors. The resultant stresses can be determined for the piping displacements as a series of calculations at discrete time intervals.

Various mathematical programmes are available for the solution of the dynamic problems, and the designer should ensure that the model and analytical methods are appropriate.

The time intervals should be chosen to ensure that no significant short-term excitation is missed, and the number of steps should ensure that all significant displacements are included in the analysis.