Safety Standards

of the
Nuclear Safety Standards Commission (KTA)

KTA 3407 (2022-11)

Pipe penetrations through the Reactor Containment Vessel

(Rohrdurchführungen durch den Reaktorsicherheitsbehälter)

Previous versions of this safety standard
were issued in 1979-06 and 2009-11.

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

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KTA SAFETY STANDARD

November 2022	Pipe penetrations through the Reactor Containment Vessel	KTA 3407

Previous versions of this safety standard: 1991-06 (BAnz. No. 113a of June 23, 1992)
2014-11 (BAnz AT 06.05.2015 B5)
2017-11 (Banz AT 17.05.2018 B8)

Contents

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Comments by the editor:

Taking into account the meaning and usage of auxiliary verbs in the German language, in this translation the following agreements are effective:

shall	indicates a mandatory requirement,
shall basically	is used in the case of mandatory requirements to which specific exceptions (and only those!) are permitted. It is a requirement of the KTA that these exceptions - other than those in the case of **shall normally** - are specified in the text of the safety standard,
shall normally	indicates a requirement to which exceptions are allowed. However, the exceptions used, shall be substantiated during the licensing procedure,
should	indicates a recommendation or an example of good practice,
may	indicates an acceptable or permissible method within the scope of this safety standard.

Basic principles

(1) The safety standards of the Nuclear Safety Standards Commission (KTA) have the task of specifying those safetyrelated requirements which shall be met with regard to precautions to be taken in accordance with the state of science and technology against damage arising from the construction and operation of the plant (Sec. 7, para. (2), subpara. (3) Atomic Energy Act - AtG) in order to attain the protective goals specified in the AtG, the Radiation Protection Act (StrlSchG) and the Radiation Protection Ordinance (StrlSchV) as well as further detailed in the Safety Requirements for Nuclear Power Plants (SiAnf) and the Interpretations of the SiAnf.

(2) Requirements for pipe penetrations through the reactor containment vessel are contained in the Safety Requirements for Nuclear Power Plants in Requirement No. 3.6, “Requirements for the Safety Enclosure” as well as in Sec. 6 “Containment” of Interpretation I-2 “Requirements for the design of the reactor coolant pressure boundary, the external systems as well as the containment”. Here, distinction is made between reactor containment penetrating pipes connected to the reactor coolant or the inner atmosphere of the reactor containment vessel and such pipes not connected to the reactor coolant or the inner atmosphere of the reactor containment vessel.

(3) Containment vessel penetrating pipes shall be so designed and constructed as to safely withstand the loadings resulting from pressure and temperature in the reactor containment vessel.

(4) The pipe penetrations covered by this safety standard are intended to have fluid pipes penetrated through the reactor containment vessel wall such that the pipes are pressure-resistant and gas leak-tight. This results in designs with or without bellows expansion joints depending on the loadings on the individual pipe, the reactor containment vessel and their mutual influences.

(5) Pipe penetrations are of special importance as they have to meet the safety-related and operational requirements for both the reactor containment vessel and the piping. In this connection, the following requirements to be harmonized for pipe penetrations shall be met:

a) ascertainment of the enclosure of the reactor containment vessel atmosphere during operation
b) ascertainment of the enclosure of the reactor containment vessel atmosphere during loss-of-coolant accidents
c) requirements from the penetrating piping systems
d) requirements from postulated failure of fluid piping

With respect to the safety requirements Clause 4.1 defines specific sections.

(6) This safety standard only lays down requirements for penetrations. In addition, reference is made to:

a) KTA 3201.1, KTA 3201.2 and KTA 3201.3
b) KTA 3211.1, KTA 3211.2 und KTA 3211.3
c) KTA 3401.2, KTA 3401.3 und KTA 3401.4

Note:

For operational and safety reasons a reactor containment vessel is provided with air locks, pipe and cable penetrations. The respective requirements are contained in:

KTA 3402	*Air locks through the Containment Vessel of Nuclear Power Plants - Personnel Locks*
KTA 3403	*Cable Penetrations through the Reactor Containment Vessel*
KTA 3409	*Air Locks for the Reactor Containment Vessel for Nuclear Power Plants - Material Locks*

KTA 3404 applies to the isolation of operating system pipes penetrating the containment vessel in the case of release of radioactive substances into the containment vessel.

1 Scope

(1) This safety standard shall apply to pipe penetrations through the reactor containment vessel made of steel for nuclear power plants with light-water reactors. For pipe penetrations through concrete reactor containment vessels with liner this safety standard may be applied accordingly taking the provisions under building law into account.

(2) The pipe penetration comprises

a) all components between the sleeve in the containment vessel and the fluid pipe including the attachment weld to the containment vessel sleeve
b) the fluid pipe between inner and outer isolation valve. Where no inner isolation valve is provided, the first accessible circumferential pipe weld outside the containment vessel is considered to be the boundary.

(3) The sleeves welded into the containment vessel and the isolation valves are not considered to be part of the pipe penetration.

(4) In the case of pipe penetrations where both isolation valves are located outside the containment vessel, the fluid pipe between these isolation valves is considered to be part of the pipe penetration.

(5) Requirements for the pressure-retaining wall of isolating devices are not covered by this safety standard.

Note:

Requirements are contained in:

KTA 3201	*Components of the Reactor Coolant Pressure Boundary of Light Water Reactors, Parts 1 to 3*
KTA 3211	*Pressure and Activity Retaining Components of Systems outside the Reactor Coolant Pressure Boundary, Parts 1 to 3*
KTA 3601	*Ventilation Systems in Nuclear Power Plants*

2 Definitions

(1) Design loading levels

In the penetration section components of pipe penetrations with the same requirements are assigned to design loading levels R1 to R3.

a) Design loading level R1 covers the requirements for components of pipes used for enclosing the reactor coolant and the reactor containment vessel boundary.
b) Design loading level R2 covers the requirements for components of pipes of specific safety-related importance with regard to their failure (see general specification on the "Basis safety of pressurised components") and the enclosure of the reactor containment vessel atmosphere.
c) Design loading level R3 covers the requirements for components not to be assignable to design loading levels R1 or R2, as the enclosure of the reactor containment vessel atmosphere is ensured by a second barrier.

(2) Welding end

The welding end is the connection between the respective bellows end and the connecting pipe penetration and containment vessel end (see **Figure 2-1**).

(3) Working pressure

The working pressure of a fluid is the inner or outer gauge pressure intended for the course of one or several basic operations in a plant component.

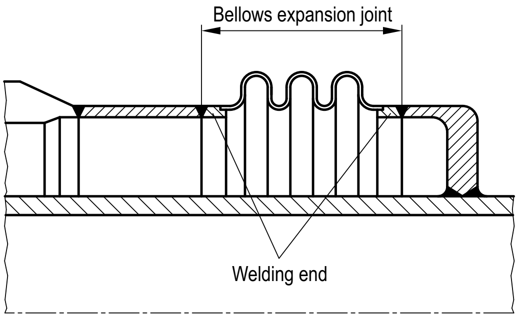


Figure 2-1: Welding end

(4) Operating temperature

The operating temperature of a fluid is the temperature intended for the course of one or several basic operations in a plant component.

(5) Bellows

A bellows is a convoluted pipe the convolutions of which are capable of performing axial, angular and lateral movements due to their flexibility. Reinforcing collars (see **Figure 2-2**) and parts for guiding the convolutions are not part of the bellows.

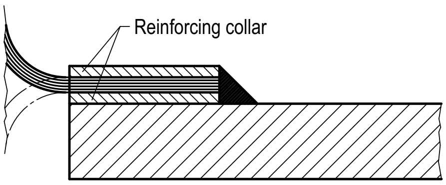


Figure 2-2: Reinforcing collar

(6) Bellows expansion joint

The bellows expansion joint is a component consisting of the two welding ends and the parts of guided expansion joints, if any (see **Figure 2-3**).

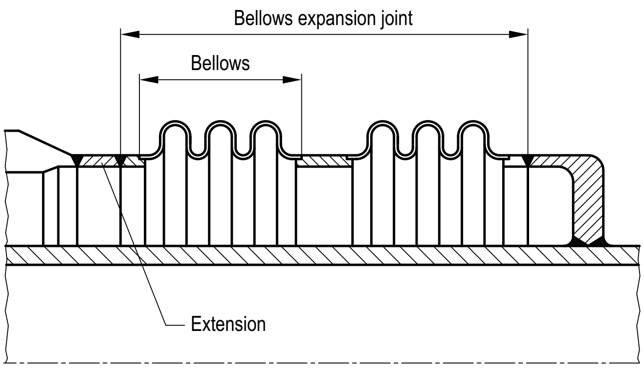


Figure 2-3: Bellows expansion joint

(7) Components of pipe penetrations

Components of pipe penetrations are (see **Figure 2-4**):

a) fluid pipes inside or outside the penetrated section

b) anchor plates, forged on or welded on

c) discharge or extension pipes

d) integral or non-integral support structures

e) bellows expansion joints.

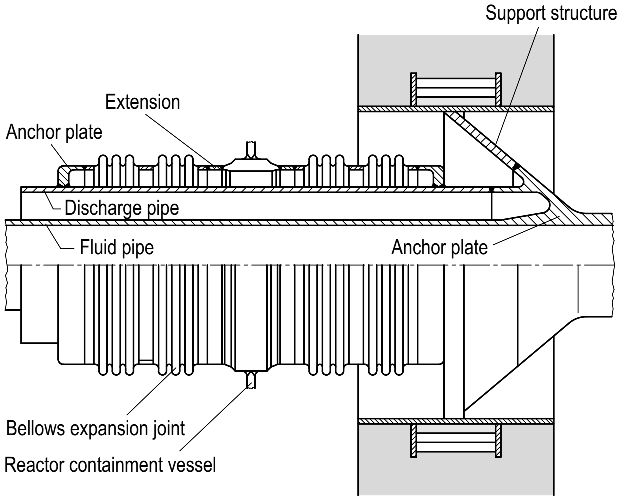


Figure 2-4: Components of pipe penetrations

(8) Penetrating section

The penetrating section is the section between the attachment welds of the fluid pipe as per **Figure 4-1**.

(9) Individual part groups

Components of pipe penetrations have been assigned to individual part groups 1 (EG 1) and 2 (EG 2) as follows:

a) Part group EG 1 comprises components subject to a pressure differential between the atmosphere and the fluid pipe. Connecting elements which connect these components as well as attachment welds to these components and to integral support structures are assigned to part group EG 1.

b) Part group EG 2 comprises components welded to part group EG 1 components including their attachment welds.

Examples for assigning components to part group EG 1 and EG 2 are given in **Table 2-1**.

Part group 1 (EG 1)	Part group 2 (EG 2)
a) Pipes (fluid pipes, discharge pipes and extension pipes) b) Pipe bends c) Anchor plates d) Bellows expansion joints e) Nozzles for test connections f) Attachment welds on part group EG 1 components g) Attachment welds of guide plates to containment vessel sleeve h) Flanges and flanged joints i) Welded attachments for integral support structures	a) Guide plates and lugs b) Attachment welds of guide plates to wall pipes not belonging to the containment c) Vent pipes within the enclosure

Table 2-1: Examples for assignment of components to part groups EG 1 and EG 2

(10) Clamp weld

A clamp weld is an edge-weld without groove by which the ends of the individual layers of multi-ply bellows expansion joints are welded.

(11) Fluid pipes

These are pipes used for the transport of liquid or gaseous fluids or steam.

(12) Pipe penetrations

Pipe penetrations are designed to permit the pressure-resistant and gas leak-tight penetration of fluid pipes through the reactor containment vessel.

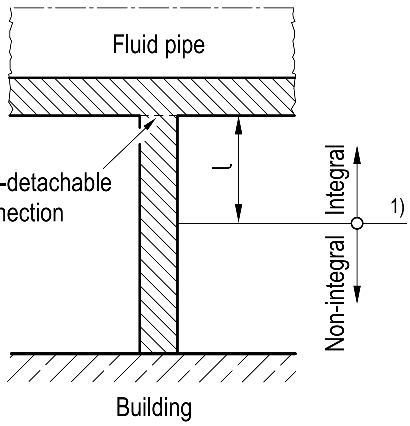
(13) Authorized inspector

The authorized inspector for the tests and inspections to be conducted in accordance with this safety standard is the authorized inspector called in by the licensing or supervisory authority in accordance with Section 20 of the Atomic Energy Act. The inspections/reviews required by this safety standard shall be performed on the basis of applications made by the competent authority.

(14) Support structures

a) Integral support structures

Integral support structures are components which are rigidly attached to the pipe or pipe penetration (e.g. welded, forged, machined from the solid) and have support functions (see **Figure 2-5**).



1) Limit of area of influence of fluid pipe

Figure 2-5: Schematic representation of integral support structures

Here, areas are concerned which are directly attached to the pressure-retaining wall of the pipe and are within the die-out length „l" (see **Figure 2-6**). Where a detachable connection is provided within the die-out length „l", the boundary between integral and non-integral support structure lies at the point of attachment (see **Figure 2-7**). The die-out length „l" for shells (e.g. tubular nozzles or skirts) shall be determined as follows:

$$l = 0.5 \cdot \sqrt{\bar{r} - s_N}$$

where:

$\bar{r}$: mean radius of pipe

s_N : nominal wall thickness of the pipe, exclusive allowances

b) Non-integral support structures

Non-integral support structures are components which are detachably connected to the pipe or pipe penetration (e.g. bolted or studded) and components having support functions which are provided in areas outside the die-out length „l" (see **Figures 2-5 to 2-7**).

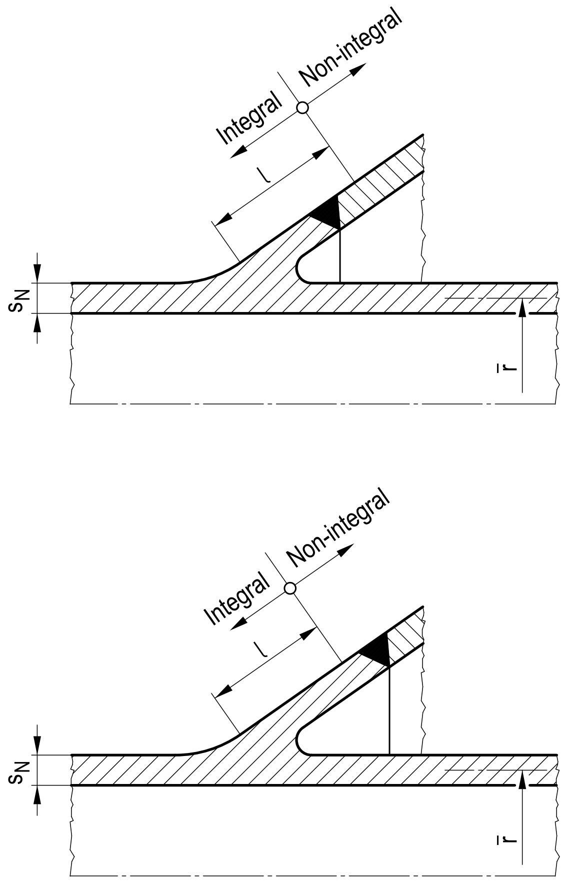
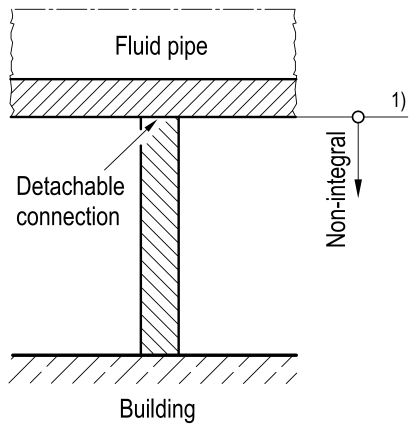


Figure 2-6: Examples of support structures



1) Limit of area of influence of fluid pipe

Figure 2-7: Schematic representation of non-integral support structure

(14) Reactor containment

The reactor containment is the system comprising the containment vessel and its surrounding building as well as the auxiliary systems for trapping and filtering leaking fluids, if any, from the reactor containment vessel.

(15) Allowable working pressure

The allowable component working pressure is the highest internal or external pressure at which this component is allowed to operate, on account of its material and the design principles, at the allowable operating temperature for trouble-free operating conditions.

3 Materials

(1) For components and welds of part group EG 1 the following materials are permitted

a) for design loading level R1, the materials to KTA 3201.1 and the welding filler metals and consumables to KTA 3201.3,

b) for design loading level R2, the materials to KTA 3211.1 and the welding filler metals and consumables to KTA 3211.3,

c) for design loading level 3, the materials, filler metals and consumables to **Annex B**.

The lowest temperature to be withstood by ferrite, which is used in the acceptance testing of base metals and filler metals, shall be the temperature of pressure testing for the reactor containment vessel. The lowest temperature to be withstood by the pipe shall suffice if, during pressure testing of the reactor containment vessel, the primary membrane stresses in the component under consideration only amount to 20 % of the yield strength of the material. Otherwise, the lowest temperature of the reactor containment vessel shall apply.

(2) For components and welds of part group EG 2, the materials to **Annex B** are permitted for design loading levels R1 to R3.

(3) The requirements for bellows expansion joint materials are laid down in **Annex A**, section A 2.

4 Conceptual design

4.1 Safety requirements

(1) The safety and operational functions of pipe penetrations relate, on the one hand, to the reactor containment vessel function (enclosure of radioactivity, ventilation ducting) and, on the other hand, to the piping function (fluid enclosure). To fulfill this functions the integrity of the pipe penetrations shall be evidenced for specified operation and the following incidents and events:

a) Pressure build-up in the reactor containment vessel by loss-of coolant

b) Rupture of fluid pipes inside and outside the pipe penetration as per clause 4.2, subclauses 1 and 2.

(2) Combined loadings (e.g. earthquake or expansion of fluid due to heating of the enclosed fluid upon loss-of-coolant accident) are laid down in **Table 6-1**.

(3) For explosion blast wave and aircraft crash events, the fluid pipe integrity shall only be evidenced if the piping system integrity must be maintained on the occurrence of such events.

(4) With respect to the abovementioned requirements the pipe penetration shall be subdivided into the following sections (see **Figure 4-1**):

Section I: covers components having enclosure safety functions (e.g. weld end of reactor containment vessel sleeve, anchor plates, bellows expansion joints). In the case of systems open at the inside like design type II (see **Figure 5-2**) also components such as extension pipes or fluid pipes up to the first isolation valve are covered.

Section II: covers protective components for Section I and the reactor containment vessel (e.g. discharge pipe or similar designs)

Section III: covers components of the fluid pipe which at specified operation are intended to enclose the fluid. The closure of a reactor containment vessel is only relevant to safety in the case of loss-of-coolant accidents and where the emergency cooling criteria have to be satisfied. This does, however, not lead to requirements for the integrity of the piping between the isolation valves if criteria 1 (see clause 5.3, subclause 2a) is satisfied.

(5) It shall be ensured that a rupture or leakage of the fluid pipe outside Section I will not effect direct damage on Section I or on the fluid pipe on the other side of the containment vessel and that the functional capability of the building isolation valve on the other side of the containment vessel is maintained.

(6) The pipe rupture load case represents an incident (accident) for the entire pipe penetration. Components of design loading level R1 shall be designed for service loading level D of KTA 3201.2 and components of design loading levels R2 and R3 shall be designed for service loading level D of KTA 3211.2.

4.2 Postulated rupture

(1) Within Section III such ruptures (load case ST 4 and ST 5 to **Table 6-1**) shall be postulated as are assigned to the penetrating pipe.

(2) Where the accident analyses show that, at the above postulated ruptures, effects not covered by the plant design occur, additional measures shall be taken. These may be process measures, secondary protective measures or additional safety measures to exclude ruptures.

(3) Within the sections I, II and III no rupture or leakage shall be assumed to occur as individual defects in the case of enclosure service loading (load case ST 1 to **Table 6-1**).

4.3 Classification of pipe penetrations

(1) The fluid pipe shall basically be classified like the penetrating pipe. For penetrating pipes not covered by KTA safety standards, **Annex B** shall apply.

Note:

For pipe penetrations distinction shall be made between non-chambered (single barrier) and chambered (double barrier) designs.

(2) The requirements for the safety enclosure integrity are deemed to have been satisfied if the requirements assigned to the classification hereinafter are met for the components of the penetrated section. The following shall apply:

a) Design loading level R2 if a protective barrier is provided.

A classification into design loading level R3 instead of R2 is permitted for penetrating pipes if a protective barrier is provided, the anchor plate and the fluid pipe are integrally forged, austenitic steel or a ferritic steel allowable for the reactor containment vessel has been used and oversizing of Section I (anchor plate/area of attachment to the fluid pipe) is proved. This proof shall be rendered to the authorized inspector.

Oversizing is achieved if the equivalent stress derived from the primary stresses in loading level A and loading level B is only utilized up to a maximum of 40 % of the design stress (this corresponds to a safety factor of 2.5).

b) Design loading level R3 if two barriers are provided.

(3) The classification of pipe penetration components in dependence of the penetrating pipe can be seen in **Table 4-1**. This classification shall apply accordingly for welds and integral support structures.

4.4 Bellows expansion joints

Annex A, Section A 3 lays down the requirements for the design of bellows expansion joints.

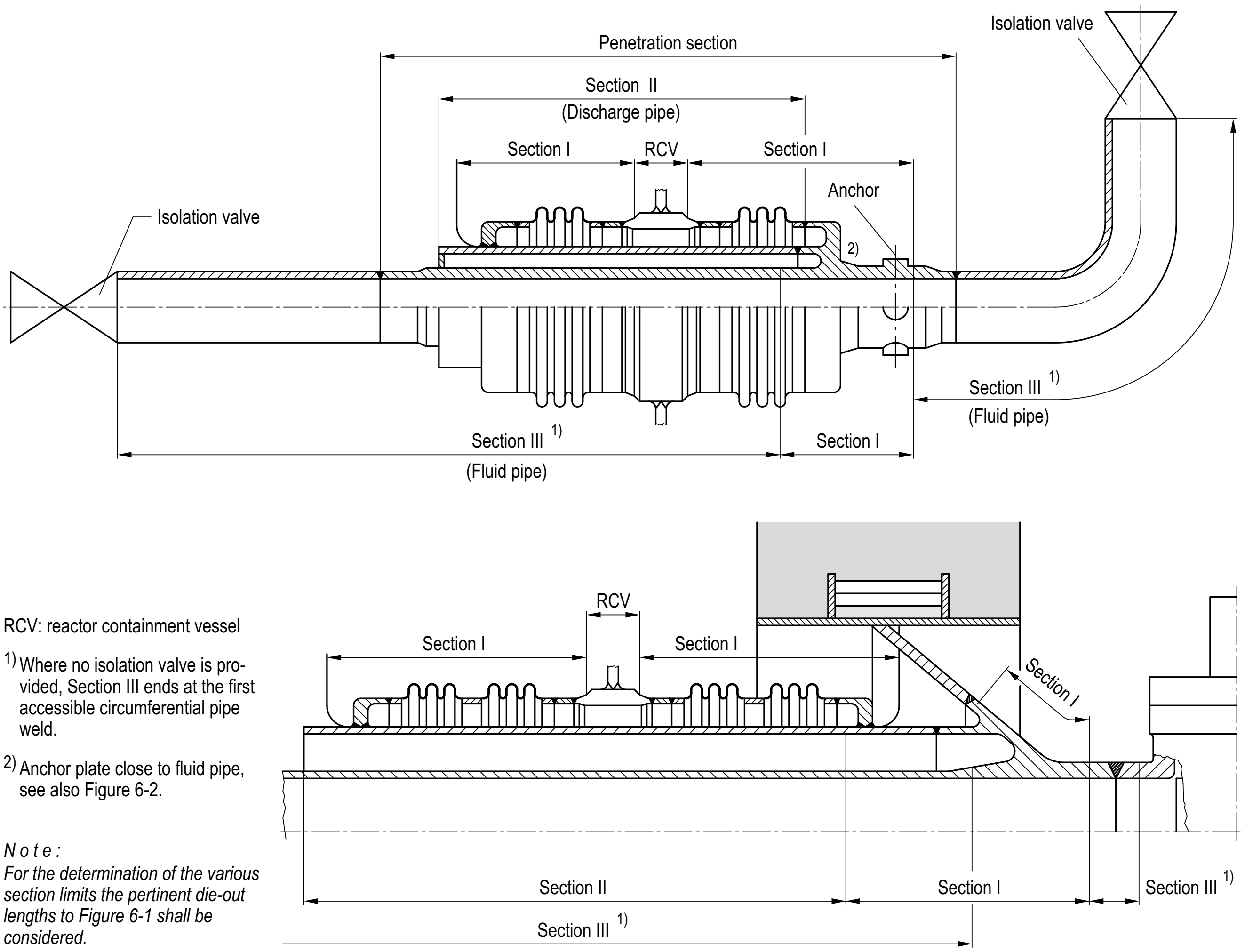


Figure 4-1: Representation of Sections I, II and III for assignment of safety requirements

Penetrating pipe covered by	Pipe penetration components						
	Fluid pipe outside the penetrated section 1)	Non-integral support structures		Fluid pipe in penetrated section 1) and forged anchor plate, if any	Welded-on anchor plate, discharge pipe and extension pipe		Bellows expansion joint
		Beam load-bearing structures	Plane load-bearing structures		Non-chambered	Chambered	
KTA 3201	KTA 3201	KTA 3205.1	Annex B	R1	R2	R3 2)	R3 2)
KTA 3211 and leak-before-break criterion (KTA 3211.3 Section 14)	KTA 3211 with additional requirements to KTA 3211.3 Section 14	KTA 3205.2	Annex B	R2 with additional requirements to KTA 3211.3 Section 14	R2	R3 2)	R3 2)
KTA 3211	KTA 3211	KTA 3205.2	Annex B	R2	R2	R3 2)	R3 2)
Technical rules beyond the scope of KTA safety standards	Annex B	KTA 3205.2	Annex B	R2 3)	R2 3)	R3 2)	R3 2)

1) For ≤ DN 50 the requirements for small dimensions shall be laid down by agreement with the authorized inspector.
2) Classification of bellows, discharge pipe and anchor plate in design loading level R2 if a single barrier is provided.
3) Classification into design loading level R3 if the proof as per clause 4.3 (2) can be made.

Table 4-1: Requirements for pipe penetration components in dependence of the classification of the penetrating pipe in due consideration of Figure 4.1

5 Design and construction

5.1 General

(1) Pipe penetrations shall basically be welded to the reactor containment vessel sleeve. Pipe penetrations welded to the reactor containment vessel are permitted by agreement with the authorized inspector if the leak tightness requirements are met (see **Figure 5-1.1**).

Note:

For certain reasons, extension pipes are used to avoid austenitic/ferritic connecting welds at the reactor safety containment.

(2) When designing pipe penetrations it shall be taken into account that the temperature of penetrating pipes may be higher than the design temperature of the reactor pressure vessel sleeve. Where required, respective insulation or heat dissipation shall be made possible to prevent the allowable temperature of the reactor pressure vessel sleeve from being exceeded.

(3) Penetrations which due to the high loading (criterion 1, see clause 5.3, subclause 1a) cannot be connected to the reactor containment vessel sleeve, shall be connected by means of bellows expansion joints. It shall be ensured by respective devices (e.g. chambered connecting area) that leak tests can be performed on the bellows expansion joints. Chambers shall be provided with nozzles for leak testing. The nozzles shall be located at the lowest point.

(4) In the case of non-horizontal pipe penetrations of design types I and IV (see **Figures 5-1.1, 5-1.2, 5-4.1**, and **5-4.2**) the components shall be arranged such as to avoid dead corners where corrosion products may accumulate.

(5) For pipe penetrations of design types III and IV the distance between the reactor containment vessel sleeve and the fluid pipe or discharge pipe shall be fixed such that no unacceptable loadings (e.g. by contact) occur in the case of operational load cases or incidents). The anchor points shall be arranged such that the bellows expansion joint is not subjected to torsional loading.

(6) A list of all pipe penetrations shall be established and updated to contain

a) type of pipe penetration
b) nominal width
c) penetrating pipe
d) classification of penetrating pipe
e) fluid
f) materials of fluid pipe
g) design data
h) identification of the reactor containment vessel sleeve. Containment vessel sleeves that are not used shall also be listed.

5.2 Arrangement

(1) Pipe penetrations shall be arranged such that

a) the penetrations through the containment vessel are arranged and designed such that an incidence at one penetration does not lead to damage on adjacent penetrations. The arrangement of pipe penetrations shall also meet the requirement for separation of redundant systems, which results from the conceptual design of the entire facility.
b) accessibility is ensured for maintenance work and in-service inspections.

(2) Short pipe lengths shall preferably be used between the isolation valves and the reactor containment vessel. In such areas, pipe branching is basically not permitted. Exceptions (such as drain nozzles, test assemblies) shall be subjected to a safety analysis.

(3) Several fluid pipes are permitted to penetrate one reactor containment vessel sleeve (see **Figure 5-1.2**). Pipes exceeding DN 25 shall basically be assigned to have the same redundancy and, if used for conveying reactor coolant, shall be isolatable. Several pipes exceeding DN 25 may even penetrate the sleeve if there are no requirements as to redundancy.

5.3 Determination of pipe penetration design types

(1) The following design types are permitted

a) design type I, rigid attachment, without chamber (see **Figures 5-1.1** and **5-1.2**)
b) design type II, rigid attachment, with chamber (see **Figure 5-2**)
c) design type III, with bellows expansion joint on both sides of the containment vessel wall, with chamber, without discharge pipe (see **Figure 5-3**)
d) design type IV, with bellows expansion joint on both sides of the containment vessel wall, with chamber and discharge pipe (see **Figure 5-4.1** and **5-4.2**)
e) special designs (rigid attachment, without chamber, with discharge pipe)

(2) The pipe penetration design type shall be determined by combining the steps to **Figure 5-5**.

a) Step 1

   It shall be checked whether, in the case of rigid attachment, the forces and moments allowable for the reactor containment vessel sleeves are exceeded due to mutual influence of piping and containment vessel during operation or incidents (criterion 1).

b) Step 2

   It shall be checked whether, upon postulated failure of the fluid pipe within Section III, as per clause 4.2, subclauses 1 and 2, the integrity of the enclosure cannot be evidenced (criterion 2),

   ba) because due to a possible consequential effect from the postulated rupture on the opposite side of Section III the integrity of the enclosure is affected, or

   bb) the opposite side cannot be isolated.

c) Step 3

   It shall be checked whether a failure (see clause 4.2) of the fluid pipe in Section III leads to consequential failure in Section I or on the containment vessel (criterion 3).

d) Step 4

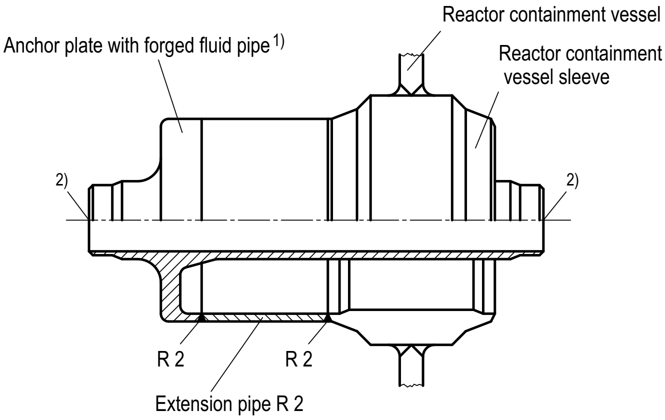
   It shall be checked whether the pipe penetration within the area of the sump water level is open to the containment vessel atmosphere, no internal isolation valve is installed and a failure of the fluid pipe to KTA 3301, clause 5.2.2.2, can be postulated during the long-time period after an incident (criterion 4).

5.4 Design meeting testing and inspection requirements

(1) Within the conceptual design of pipe penetrations care shall be taken to ensure that pressure-retaining and dynamically loaded welds can be subjected to first and in-service non-destructive tests, except for longitudinal welds on bellows. Welds that are neither accessible for in-service internal inspections nor in-service non-destructive tests, shall be limited to nominal stresses smaller than or equal to 50 N/mm^2 during operation.

(2) Chambered pipe penetrations shall make in-service leak tests possible.

Forged design

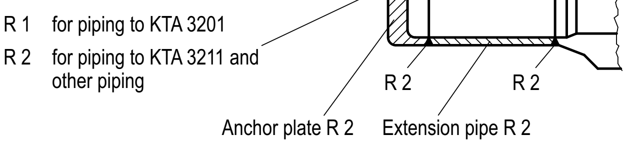


Welded design

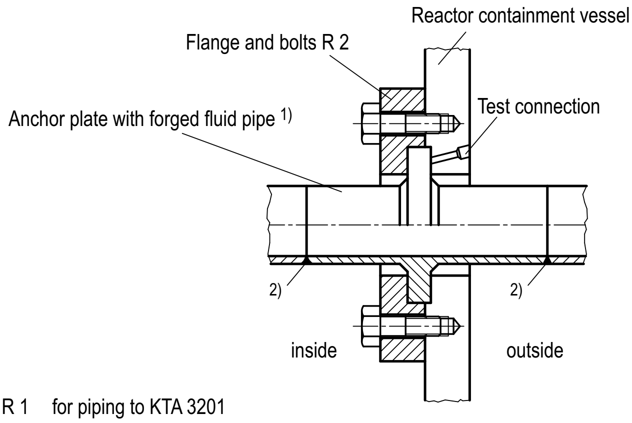
Fluid pipe:

R 1 for piping to KTA 3201

R 2 for piping to KTA 3211 and other piping



Bolted design



1) R 1 for piping to KTA 3201

R 2 for piping to KTA 3211 and other piping

R 3 for other piping if the proof to clause 4.3, subclause 2 can be provided.

2) Connecting welds to fluid pipe:

R 1 for piping to KTA 3201

R 2 for piping to KTA 3211

R 3 for other piping

Figure 5-1.1: Examples of pipe penetration of design type I with fluid pipe and identification of design loading levels R1, R2 and R3

Design with welded-in fluid pipe

Fluid pipe:

R 1 for piping to KTA 3201

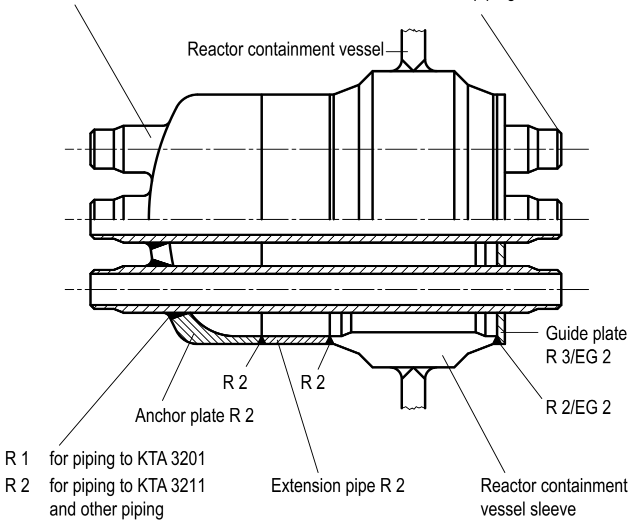
R 2 for piping to KTA 3211 and other piping

Connecting welds to fluid pipe:

R 1 for piping to KTA 3201

R 2 for piping to KTA 3211

R 3 for other piping



Design with rolled or hydraulically expanded pipe

Austenitic fluid pipe and seal welds:

R 1 for piping to KTA 3201

R 2 for piping to KTA 3211 and other piping

Connecting welds to fluid pipe:

R 1 for piping to KTA 3201

R 2 for piping to KTA 3211

R 3 for other piping

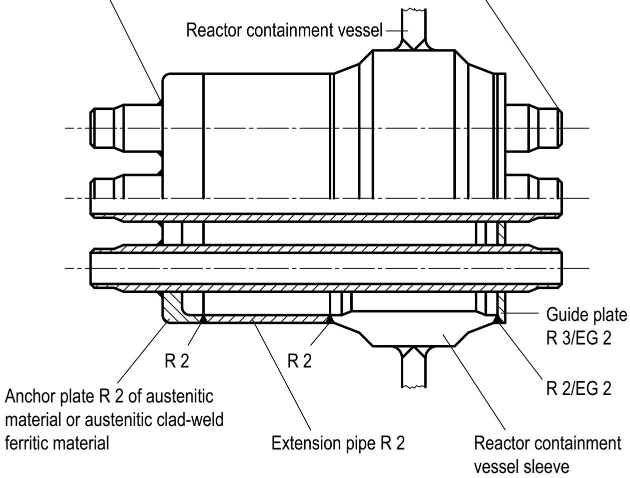
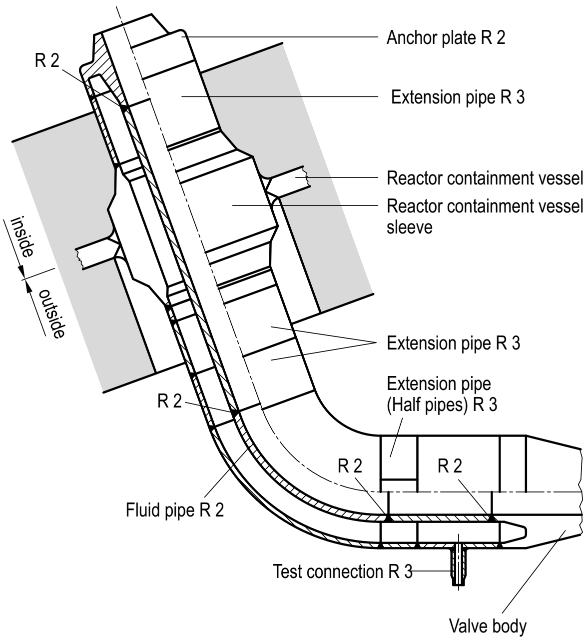
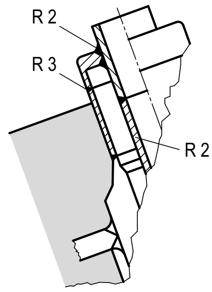


Figure 5-1.2: Example of pipe penetration of design type I with several fluid pipes and identification of design loading levels R1, R2 and R3

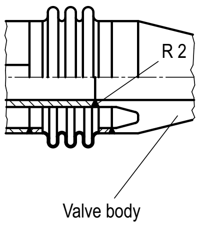
Forged anchor plate



Welded anchor plate



Design with bellows expansion joint



Unless specified otherwise: welds R 3

Figure 5-2: Example of pipe penetration of design type II and identification of design loading levels R2 and R3

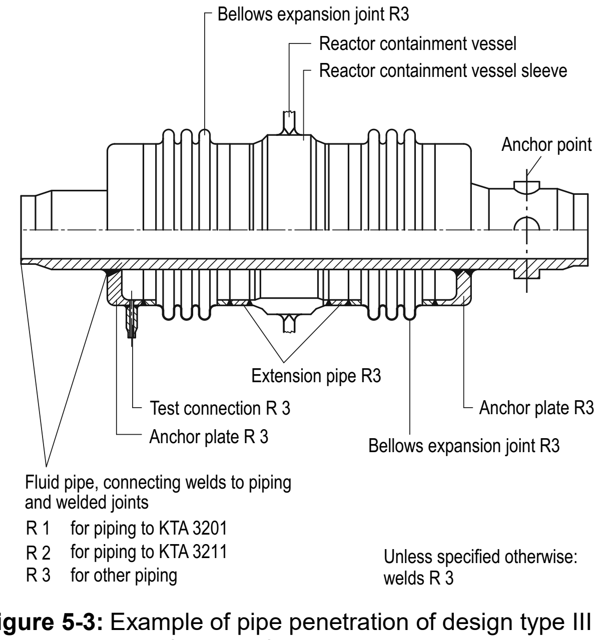


Figure 5-3: Example of pipe penetration of design type III and identification of design loading levels R1, R2 and R3

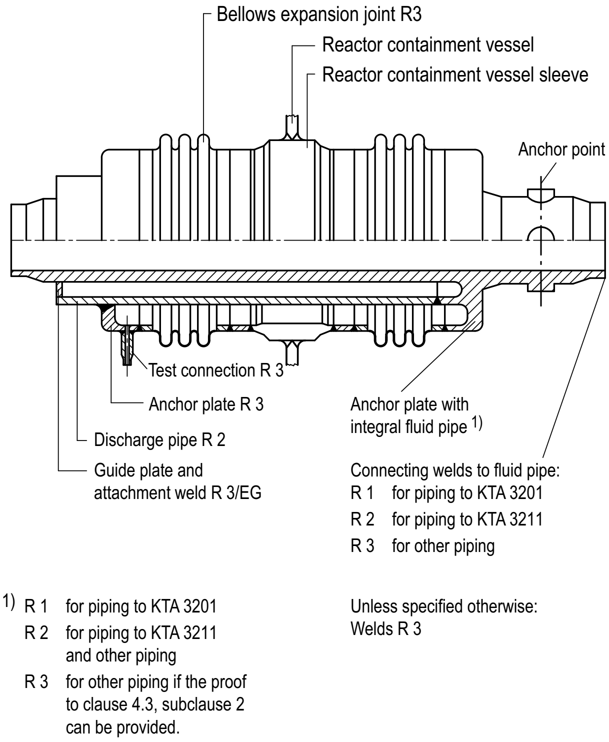


Figure 5-4.1: Example of pipe penetration of design type IV with separate anchor point and identification of design loading levels R1, R2 and R3

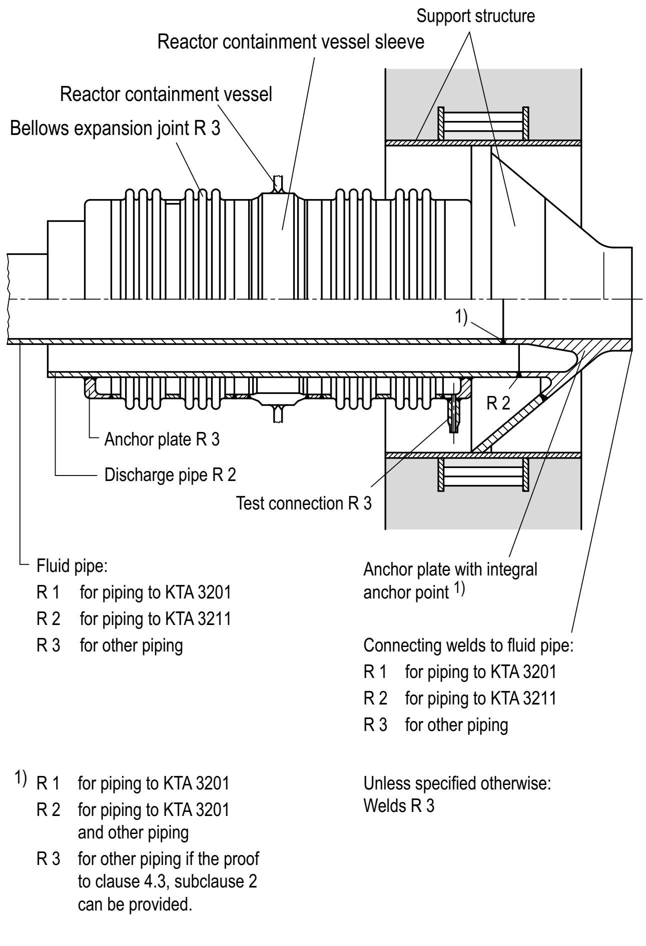


Figure 5-4.2: Example of pipe penetration of design type IV with integral anchor point and identification of design loading levels R1, R2 and R3

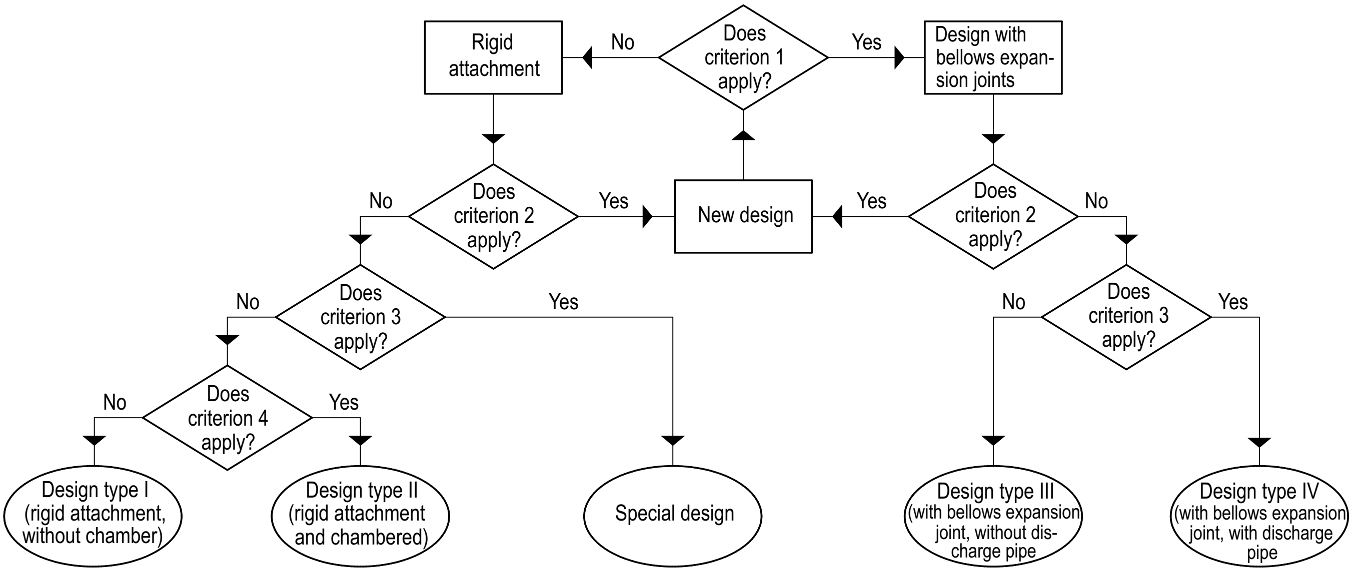


Figure 5-5: Determination of pipe penetration design types

5.5 Possibility of decontamination

The external surfaces of pipe penetrations shall make a decontamination possible. For bellows exceptions are permitted if, for design or material-specific reasons, decontamination is not possible. These exceptions shall be well founded.

5.6 Non-integral support structures

For non-integral support structures KTA 3205.1 or KTA 3205.2 shall apply.

5.7 Bellows expansion joints

The design requirements for bellows expansion joints are laid down in **Annex A**, Section A4.

6 Calculation

6.1 General

(1) The requirements of this section apply to Sections I, II (discharge pipe) and III defined in section 4. They do not apply to the reactor containment vessel sleeves outside Section I.

Note:

The sleeves welded into the containment vessel shall be calculated in accordance with KTA 3401.2. For the selection of pipe penetration design types the allowable forces and moments for the sleeves shall be indicated.

(2) According to the classification of **Table 4-1** the following KTA safety standards shall apply to the calculation:

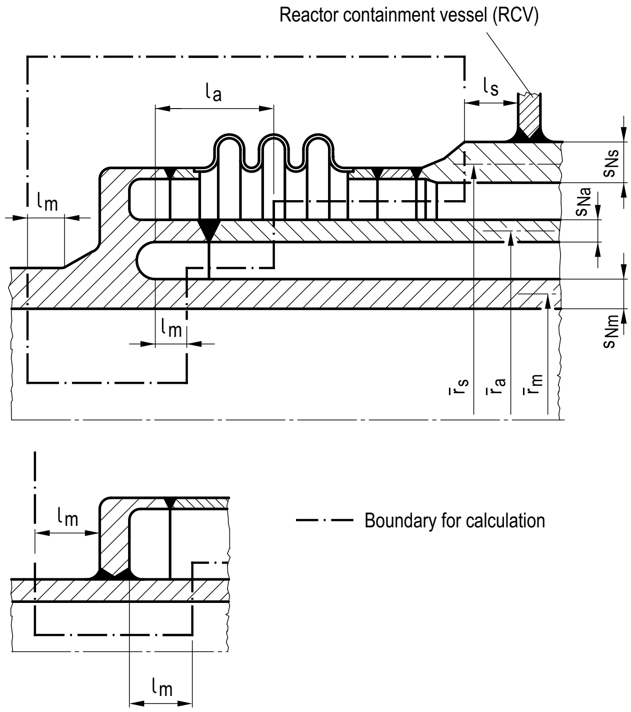
a) KTA 3201.2 for components of pipe penetrations of design loading level R1,

b) KTA 3211.2 for components of pipe penetrations of design loading level R2,

c) KTA 3211.2, test group A2 for components of pipe penetrations of design loading level R3.

(3) Differing from the KTA safety standards listed in (2), **Figure 6-1** shall apply with respect to the boundary of Section I for the pipe penetration. This boundary does not apply to the classification of components and welds (see also clause 4.3).

(4) Irrespective of the classification of the components and welds into design loading levels R1 to R3, **Table 6-1** shall apply with respect to the combined loadings and the classification into service loading levels.



Determination of die-out lengths

$$l_m = 0.5 \cdot \sqrt{\bar{r}_m \cdot s_{Nm}}$$

$$l_s = 0.5 \cdot \sqrt{\bar{r}_s \cdot s_{Ns}}$$

$$l_a = 0.5 \cdot \sqrt{\bar{r}_a \cdot s_{Na}}$$

Notation:

s_N	:	nominal wall thickness (excluding allowances)
s_{Nm}	:	nominal wall thickness of fluid pipe
s_{Ns}	:	nominal wall thickness of RCV sleeve
s_{Na}	:	nominal wall thickness of discharge pipe
l_m	:	die-out length of fluid pipe
l_s	:	die-out length of RCV sleeve
l_a	:	die-out length of discharge pipe
$\bar{r}_m$	:	mean radius of fluid pipe
$\bar{r}_s$	:	mean radius of RCV sleeve
$\bar{r}_a$	:	mean radius of discharge pipe

Figure 6-1: Limitation of Section I of pipe penetration for the purpose of the calculation as per clause 4.1

(5) The only load case to be considered for Section II shall be rupture or leak of the respective fluid pipe.

(6) Requirements for the calculation of bellows expansion joints can be found in **Annex A**, Section A5.

6.2 Contained fluid load case

(1) Where in pipe penetrations the operating temperature is less than the temperature occurring in the case of loading of the reactor containment vessel, it shall be additionally proved for the section between the isolation valves outside the die-out lengths to **Figure 6-1**, that the pressure is limited, e.g. by load-induced leakage of the valve body seat or by response of the body breaking pin device (safety valve) in the case of gate valves. For the calculation, the following loadings shall be combined:

a) Loadings imposed by the fluid pipe
   - operating pressure
   - dead weight
   - pressure build-up due to heating of the contained fluid

b) Loadings imposed by the containment vessel:
   - possible overpressure (operating pressure)
   - local pressure build-up

c) Loadings imposed by relative movements between fluid pipe and containment vessel in due consideration of restraints to thermal expansion.

(2) The reference temperature for the determination of the allowable stresses is the fluid pipe temperature occurring at loss-of coolant accidents.

(3) **Figure 6-2** contains the assignment of service loading levels to cover primary stresses.

6.3 Calculation of non-integral support structures

The calculation of non-integral support structures shall be made for

a) beam load-bearing structures to
   - aa) KTA 3205.1 in the case of pipe penetrations for piping covered by KTA 3201
   - ab) KTA 3205.1 in the case of pipe penetrations for piping covered by KTA 3211 and technical rules beyond the scope of KTA safety standards

b) plane load-bearing structures to KTA 3211.2, test group A2.

1		2															3	4						5
Loading levels		Loadings (for the respective load application it shall be checked in consideration of the classification, which loadings apply)																						Load cases to KTA 3401.2
		Loadings imposed by the fluid pipe															Loadings imposed by relative movement between fluid pipe and reactor containment vessel. Discharge pipe and reactor containment vessel or displacement at points of attachment for design types 1 and 2	Loadings imposed by the reactor containment vessel (RCV)						
		Static loadings							Transient or dynamic loadings															
												Loadings due to external hazards												
		Allowable working pressure	Allowable operating temperature [3]	Working pressure	Operating temperature [3]	Dead weight and other permanent loads	Restraint to thermal expansion	Test loadings	Transient operational loads	Anomalous loadings	Mechanical operational loads, re-action forces	Design basis earthquake	Aircraft crash	Clouds of gas explosion	Effects from the outside (pipe rupture)	Pressure build-up due to heating of contained fluid [7]		Allowable working pressure	Allowable operating temperature [3]	Working pressure	Local pressure build-up	Operating temperature [3]	Test loadings	
Design loadings	0		X			X											X	X	X					DF 1
		X	X			X																		—
Service loadings	A			X	X	X	X		X		X [2]						X			X		X		NB
	B			X	X	X	X		X	X						X	X			X	X	X		ST 1 [6]
				X	X	X	X		X	X							X			X		X		NB
	P				X	X											X			X		X	X	DP 1, DP 2
				X	X	X		X																NB
	C			X	X	X					X [2]						X							—
	D			X	X	X									X		X			X		X		ST 4
				X	X	X									X		X			X		X		ST 5
				X	X	X					X [2]	X					X [1]			X		X		ST 6
	[5]			X	X	X					X [2]		X [4]				X [1]			X		X		ST 6
	[5]			X	X	X					X [2]			X			X [1]			X		X		ST 6

[1] RCV sleeve movement due to external hazards shall be considered.

[2] Mechanical load portions shall be considered if required due to time history.

[3] The temperature basically governs the determination of the allowable stress.

[4] Where an equivalent statical method is used, the stresses shall be safeguarded in accordance with this method.

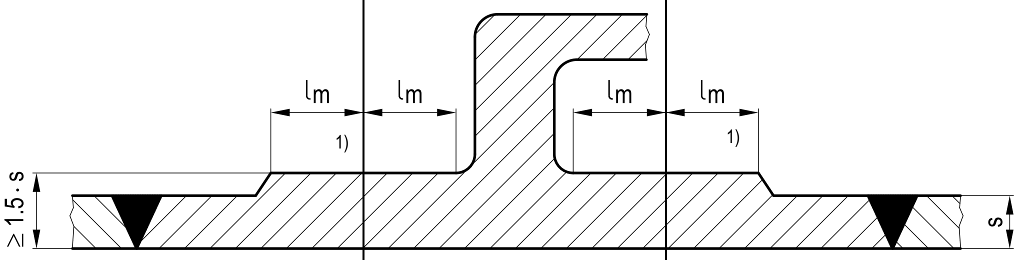
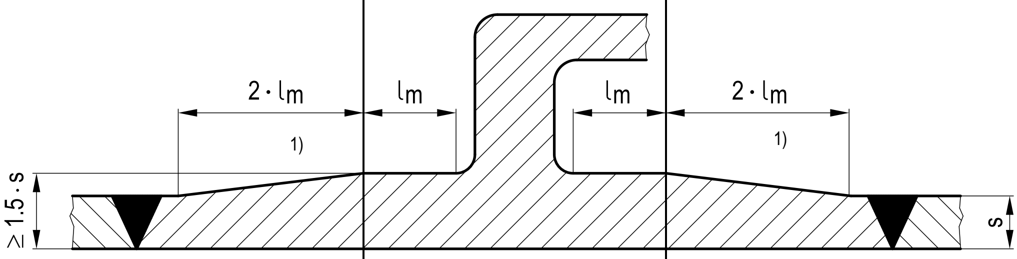
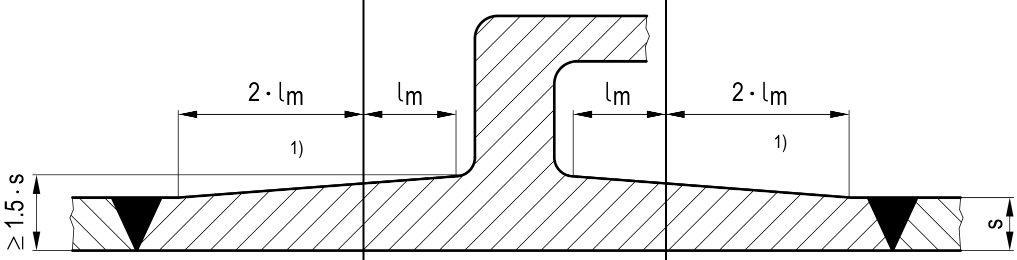
[5] Only pipe penetrations, the integrity of which is required regarding the penetrating pipe.

[6] The fluid pipe shall be safeguarded by service level D unless further requirements have to be met by the penetrating pipe.

[7] See clause 6.2.

X : Loading shall be considered

Table 6-1: Principal superposition of loadings and their classification into loading levels for the calculated section as per **Figure 6-1**

Design requirement	Sections to Figure 4-1 Section III (Fluid pipe)	 Section I	 Section III (Fluid pipe)
Stepped wall thickness transition			
Conical wall thickness transition			
Conical transition			
Assigned loading level	D for design loading levels R1 and R2 for all materials D for design loading level R3 for austenitic materials and 15 MnNi 6 3 C for design loading level R3 for all other materials	B for design loading levels R1, R2 and R3 in connection with Table 6-1	D for design loading levels R1 and R2 for all materials D for design loading level R3 for austenitic materials and 15 MnNi 6 3 C for design loading level R3 for all other materials
	Design loading levels C or D shall only be substantiated by way of calculation for the unreinforced area.		

1) Required if fluid pipe is assigned to design loading level R3.

Figure 6-2: Design requirements and determination of loading levels of pipe penetrations to withstand the load case „contained fluid“ where loading level C or D is assigned to the fluid pipe

7 Design approval and manufacture

(1) The requirements of **Table 7-1** apply to the design approval, manufacture, acceptance and final inspections of pipe penetration components.

Pipe penetration components	Design loading level		
	R1	R2	R3
Part group EG 1 (without bellows expansion joints)	KTA 3201.3	KTA 3211.3	Annex B
Part group EG 2	Annex B	Annex B	Annex B
Integral support structures	KTA 3201.3	KTA 3211.3	Annex B
Non-integral support structures			
Beam load-bearing structures	KTA 3205.1	KTA 3205.2	KTA 3205.2
Plane load-bearing structures	Annex B	Annex B	Annex B
Bellows expansion joints	1)	Annex A	Annex A

1) Classification into design loading level R1 is not intended (see **Table 4-1**)

Table 7-1: Requirements for design approval and manufacture of pipe penetration components

(2) When determining the extent of and requirements for the procedure and production tests, the lowest temperature of the load imposed during pressure testing of the reactor containment vessel shall be considered. The lowest temperature of the fluid pipe will suffice if during pressure testing of the reactor containment vessel, the primary membrane stresses in the component under consideration only amount to 20 % of the yield strength of the material. Otherwise, the lowest temperature of the reactor containment vessel shall apply.

8 Transportation and storage

8.1 Transportation

(1) Bellows expansion joints shall be packed by the manufacturer such that contaminations can be excluded. Bellows expansion joints shall be secured against impacts, vibrations and deformations during transportation.

(2) For components with anti-corrosion coating care shall be taken to ensure that the coating is not damaged.

(3) Austenitic pipe penetration components shall be transported such that a contamination by ferrites and damage to the surface passivation layer is avoided.

8.2 Storage

Pipe penetration components shall be stored such that the surface condition obtained for the intended use is not changed. Within the receiving inspection of deliveries, the specified surface condition shall be checked.

9 Installation

9.1 General

For bellows expansion joints the type of pressure loading and direction of movement as well as the pre-stressing shall be considered, and the required protection against damage during construction shall be provided.

(2) The insulations of fluid pipes shall not restrain the free movement of the bellows.

(3) The welding and inspection of site welds shall be effected to meet the requirements of Section 7.

9.2 Inspections upon installation

9.2.1 Workmanship

The quality of workmanship shall be checked by the authorized inspector to cover

a) a check for proper installation of the pipe penetrations by means of the design approval documents,
b) an inspection of the bellows surfaces,
c) a check of the anti-corrosion coating,
d) a control of the cleanliness.

9.2.2 Pressure and leak tests

(1) The pipe penetration components shall be tested within the pressure test of the reactor containment vessel to KTA 3401.3 and within the leak tests of the reactor containment vessel to KTA 3405.

(2) In the case of chambered pipe penetrations, the chamber shall be subjected, prior to the reactor containment vessel pressure test,

a) to a gas pressure test with 1.1 times the allowable working pressure of the bellows expansion joint and
b) to a leak test, e.g. helium sniffing test, pressure rise test, pressure decay test to DIN EN 1779.

(3) In the leak test a leak rate relating to helium of up to 10^{-4} Pa · m^3 · s^{-1} is permitted.

(4) Where welds on the fluid pipe in the penetrated section are inaccessible for the first system pressure test, a separate partial pressure test shall be performed to permit inspection of the covered welds.

10 Documentation

The data required for documentation shall be taken from:

a) KTA 3201.3 for pipe penetration components of design loading level R1,
b) KTA 3211.3 for pipe penetration components of design loading level R2,
c) **Annex B** for pipe penetration components of design loading level R3.

11 In-service inspections

In-service inspection shall be performed in accordance with KTA 3401.4.

Annex A

Bellows expansion joints

Contents

A 1 Application

This Annex shall apply to bellows expansion joints of reactor containment vessel pipe penetrations.

A 2 Materials

A 2.1 Bellows

A 2.1.1 Selection of materials

Solution-annealed austenitic steels of the material numbers 1.4541, 1.4550 (not for strips) and 1.4571 shall normally be used. Other materials are subject to agreement by the authorized inspector.

A 2.1.2 Requirements for materials

The values of DIN EN 10028-7 shall apply.

A 2.1.3 Materials testing and certificates

For the testing and certification of materials AD 2000-Merkblatt W2 shall apply.

A 2.1.4 Requirements to be met by the manufacturer

Regarding the requirements to be met by the manufacturer, AD 2000-Merkblatt W0, Section 3 shall apply.

A 2.2 Welding ends, components and small parts

For the selection of materials and the acceptance of the products, the requirements of the following standards apply:

a) KTA 3211.1 for design level loading R2

b) **Annex B** for design level loading R3.

A 2.3 Welding filler metals

For the manufacture of bellows expansion joints the following shall be used:

a) welding filler metals and consumables approved to KTA 1408.1 and fabricated to KTA 1408.2 for design loading level R2, and

b) welding filler metals and consumables approved to VdTÜV-Merkblatt Schweißtechnik 1153 for design loading level R3.

A 3 Conceptual design

(1) The stress and fatigue analysis of bellows expansion joints shall consider the following loadings:

a) the design pressure of the reactor containment vessel,

b) the design temperature of the reactor containment vessel,

c) the relative movements arising between the reactor containment vessel sleeve and the fluid pipe or double pipe.

(2) The pressure and temperature possible in the chamber of chambered pipe penetrations (e.g. in the case of fluid pipe leakage) shall be considered.

(3) For the assignment of bellows expansion joints to loading levels, **Table 4-1** applies.

A 4 Construction

A 4.1 Bellows

(1) Single-ply and laminated bellows (not more than 5 plies) may be used.

(2) Multi-ply bellows (more than 5 plies) are basically not permitted due to design uncertainties and the risk of damage. Where, in individual cases, bellows with more than 5 plies are to be used, the design and calculation requirements and further requirements, if any, which deviate from the requirements of **Annex A**, shall be laid down within the design approval procedure.

(3) In the case of fillet welds and inserted butt welds, cyclic plasticisation at the root of notch shall be avoided. This may e.g. be achieved by a reinforcing collar.

(4) In the case of laminated bellows, it shall be ensured by the arrangement of seal and supporting layers that no pressure can build up between the layers due to leakage.

(5) Contact between the bellows convolutions is basically not permitted. Exceptions shall be substantiated for each individual case.

(6) Allowances to the design wall thickness are not permitted.

(7) Care shall be taken to ensure that the bellows are not damaged during transportation and storage.

A 4.2 Welding ends

A 4.2.1 Design types

The design types shown in **Figure A 4-1** are permitted for connecting the bellows to the tangent of the expansion joint.

A 4.2.2 Tolerances

(1) The following tolerances shall be adhered to:

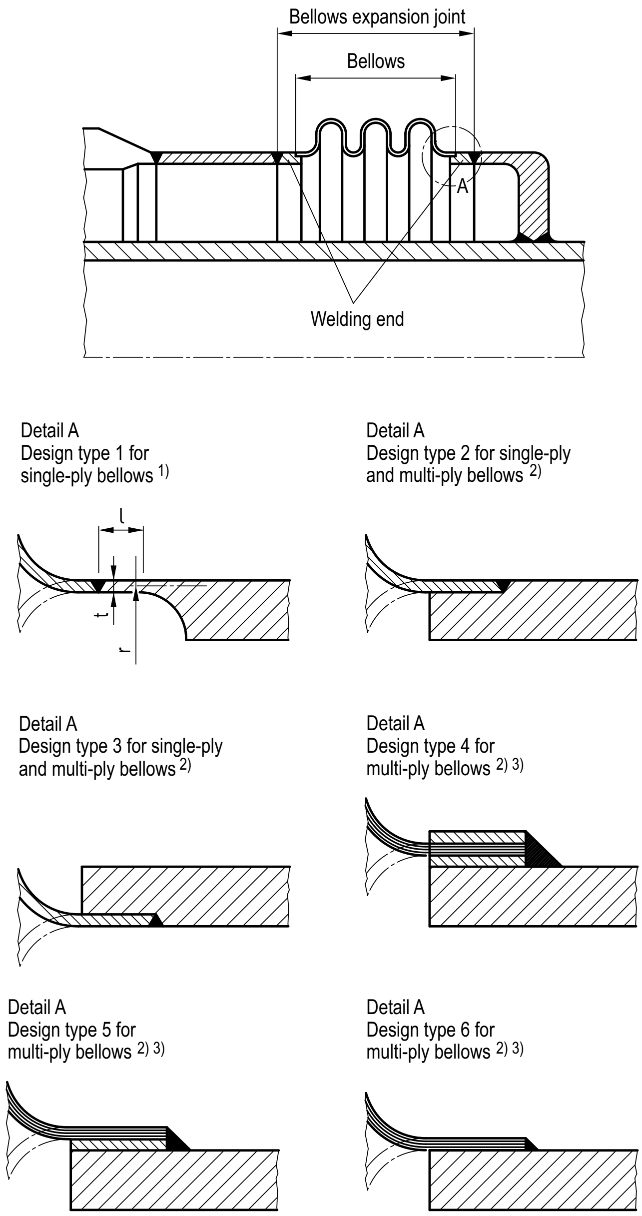
a) to DIN EN ISO 1127 for seamless and longitudinally welded pipes made of austenitic materials,

b) to DIN EN 10216-1 or DIN EN 10216-2 for seamless pipes made of ferritic materials,

c) to DIN EN 10217-1 or DIN EN 10217-2 for longitudinally welded pipes made of ferritic materials,

d) to DIN ISO 2768-1 tolerance class "medium" as minimum requirement for linear and angular dimensions on machined parts.

(2) For the linear misalignment the requirements of KTA 3211.3 apply.



1) To limit the effective length the following applies: $l \le 0.5\sqrt{r \cdot t}$

2) Bellows and reinforcing collars shall be so attached that a tight fit to the welding end is ensured.

3) Only permitted if classified into design loading level R3 and in the case of welding ends and reinforcing collars made of austenitic material.

Figure A 4-1: Design types for bellows connections

A 4.3 Bellows expansion joints

A 4.3.1 Connection of bellows

The bellows shall be connected to welding ends as shown in **Figure A 4-1**. The tolerances of the assembly dimensions shall be as little as possible. The edge conditions shall be such that the welded joints can be non-destructively tested. Austenitic/ferritic joints are not permitted for design types 1, 2 and 3 (see **Figure A 4-1**).

A 4.3.2 Corrosion protection

Corrosive attack shall be counteracted by the selection of suitable materials. A wall thickness corrosion allowance is not permitted. For fillet welds and inserted butt welds the possibility of crevice corrosion shall be considered.

A 4.3.3 Welded attachments

For attachment welds used to connect welding ends to parts for guiding bellows expansion joints, fillet welds are permitted which shall be welded with a throat thickness “a” ranging from 3 mm up to 0.7 times the smallest wall thickness (see **Figure A 4-2**).

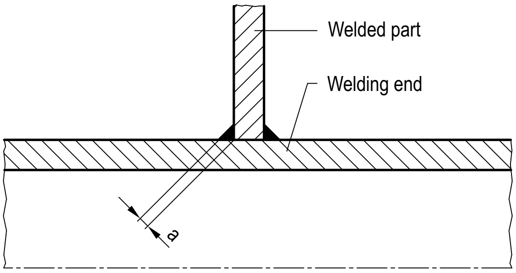


Figure A 4-2: Welded attachment

A 4.3.4 Misalignment

The allowable misalignment “e” (see **Figure A 4-3**) for the bellows longitudinal weld as well as bellows attachment weld (**Figure A 4-1**, design type 1) shall not exceed 0.1 times the bellows wall thickness.

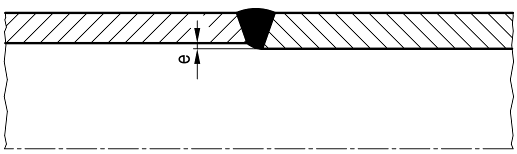


Figure A 4-3: Misalignment

A 5 Calculation

A 5.1 General

The deflections calculated for the individual bellows convolutions, which are required as input data for the strength calculation, shall be determined by suitable calculation procedures. In the elastic region, when conversion is made from lateral deflection (offset) to angular rotation (rotation angle), the rotation angle shall be determined analogously to the bent beam model by means of equation (A-1) where the notations are as follows (see **Figure A 5-1**):

W lateral displacement

B bellows length

L bellows centre-to-centre distance

x given axial compression

n number of convolutions per bellows

α maximum rotation angle of the first convolution during lateral movement, in degree. This angle shall be inserted in equation 6 of AD 2000-Merkblatt B 13.

$$\alpha = \frac{180 \cdot W \cdot \left(1 + \frac{B}{L}\right)}{\pi \cdot \left(L - \frac{x}{2}\right) \cdot \left[1 + \frac{1}{3} \cdot \left(\frac{B}{L}\right)^2\right] \cdot n} \qquad \text{(A-1)}$$

A 5.2 Proof of strength of single-ply bellows

(1) The strength verification of single-ply bellows shall be performed in compliance with AD 2000-Merkblatt B 13 or, alternatively, according to section 6 of DIN EN 14917.

(2) Differing from AD 2000-Merkblatt B 13, the following safety factors apply:

a) for the design: $S_{vp} = S_{um} = 1.5$

b) for the pressure test: $S_{vp} = S_{um} = 1.1$

(3) Differing from DIN EN 14917 a safety factor of 1.1 shall apply for the pressure test.

(4) For each bellows expansion joint it shall be proved that it is adequately dimensioned to withstand buckling or instability, e.g. by calculation of instability according to the regulation used for strength verification (AD 2000-Merkblatt B13 or DIN EN 14917) or by means of tests to be performed or having already been performed on comparable bellows expansion joints).

(5) Differing from AD 2000-Merkblatt B13 and from DIN EN 14917 the following shall apply:

a) For the calculation against fluctuating loadings to AD 2000-Merkblatt B 13 the load cycle safety factor against leakage shall be $S_L = 5$.

b) In the strength verification to DIN EN 14917

ba) the Factor K_f in the first condition in equations (91) and (92) shall be used with a value of 1.5 irrespective of the strain hardening,

bb) in the verification of column stability, a safety factor of 5 shall be used instead of a safety factor of 1.4 in all equations of clause 6.2.3.3.2.1 and a safety factor of 5 shall be used instead of the safety factor 2 in equation (93).

bc) the number of allowable load cycles determined in compliance with DIN EN 14917 shall be safeguarded with an additional safety factor of 2.5.

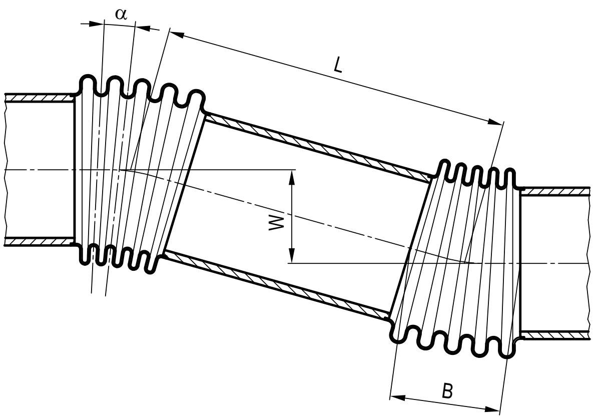


Figure A 5-1: Bent beam model

A 5.3 Proof of strength of laminated bellows

(1) The strength verification for multi-ply bellows $n_p \leq 5$ shall be made to Section 6 of DIN EN 14917.

(2) Deviating from DIN EN 14917 the following shall apply:

a) for pressure testing a safety factor of 1.1,

b) in the first condition in equations (91) and (92) the factor K_f shall be used with a value of 1.5 irrespective of the strain hardening,

c) in the verification of column stability, a safety factor of 5 shall be used instead of a safety factor of 1.4 in all equations of clause 6.2.3.3.2.1 and a safety factor of 5 shall be used instead of the safety factor 2 in equation (93).

d) in the fatigue analysis to DIN EN 14917, the number of allowable load cycles determined shall be safeguarded with an additional safety factor of 2.5.

A 5.4 The proof of strength of welding ends, components and small parts.

The requirements of KTA 3211.2 apply to the calculation.

A 6 Design approval

(1) The following documents shall be submitted to the authorized inspector for design approval:

a) cover sheet,
b) design data sheet for bellows expansion joints,
c) design drawing,
d) test and examination sequence plan (TESP) (unless a standardised TESP checked by the authorized inspector is used),
e) welding procedure sheet (in the case of fully mechanized welding procedures to ~~DIN EN 14610 and~~ DIN 1910-100 without welding filler metals the welding procedure to be used shall be indicated in the drawing instead of the welding procedure sheet; where welding filler metals are used, a welding procedure sheet shall be established,
f) calculation.

(2) For all other bellows expansion joint components, the requirements of KTA 3211.3 shall be met.

A 7 Manufacture

A 7.1 Requirement to be met by the manufacturer

(1) The bellows expansion joint manufacturer (including the bellows manufacturer) shall be qualified to AD 2000-Merkblatt HP 0. The fabrication shall be performed to design-approved documents.

(2) As regards the requirements for test supervisory personnel and operators for non-destructive testing, the requirements of KTA 3211.3, clause 3.3.4 apply.

A 7.2 Weldments

(1) KTA 3211.3 applies to the design and welding of welded joints and to the selection of welding procedures and welding filler metals for the welding ends, components and small parts.

(2) For bellows the following applies:

a) The surface of the bellows welded joints is generally undressed. The surface condition shall make non-destructive testing possible.
b) For bellows longitudinal welds the weld thickness shall not be less than the actual plate thickness.
c) For all other welds single local weld concavities are permitted if the weld thicknesses are not less than the calculated weld thicknesses and the possibility of testing is not impaired.

A 7.3 Welding procedure qualifications

(1) Prior to the beginning of manufacture, valid welding procedure qualifications to KTA 3211.3 shall be proved to the authorized inspector with respect to the materials and combinations of materials to be welded and the welding procedures to be used.

(2) Differing from KTA 3211.3 the following tests and examinations shall be performed on longitudinal welds on the unformed cylindrical bellows and for the bellows convolution root and clamp welds, and the performance of such tests and examinations shall be proved to the authorized inspector.

a) longitudinal weld on the unformed cylindrical bellows

   aa) penetrant testing to **Annex C** and assessment to AD 2000-Merkblatt HP 5/3 at a wall thickness of 1 mm and more,

   ab) 2 tensile tests to DIN EN ISO 4136 at room temperature on flat tensile specimens taken from the welded joint. By these tests, the tensile strength R_m and location of crack shall be determined.

   ac) 2 bend tests each to DIN EN ISO 5173 with root and cover layer under tension at a wall thickness of 5 mm and more. Here, the bending strain and the bending angle shall be determined. On the side under tension, the original surface of the specimen shall be maintained after dressing of excessive weld metal. In the case of thin plates, dressing can be omitted.

   For bend test specimens the following requirements apply:

   The mandrel diameter shall be 2 times the specimen thickness. A bending angle of 180° is deemed to have been obtained if the bend test was performed to DIN EN ISO 5173 and the specimen has been pressed through the supports without cracking.

   Where a bending angle smaller than 180°, but up to and including 90° is obtained, the bending strain (L_0 = weld joint width + wall thickness, symmetrical to the weld) shall correspond to the elongation at fracture A of the base material for a short proportional bar.

   Where a bending angle smaller than 90° is obtained, the bending strain over the weld joint width shall be more than 30 %, and a fracture appearance free from defects shall be obtained. In the case of dissimilar welded steels (e.g. X8Ni9, material no. 1.5662) deviating values may be specified by agreement with the authorized inspector.

   ad) 1 tensile test on a flat tensile specimen to DIN 50125 longitudinally to the weld (weld at centre of specimen) at room temperature. The following is to be determined: proportional elastic limit R_p, tensile strength R_m and elongation at fracture A for a short proportional bar.

   ae) 3 cupping tests to DIN EN ISO 20482 with the weld at specimen centre (for a wall thickness less than 3 mm) to determine the ductility of the welded joint. The cupping value shall normally be obtained in the area of the base metal.

   af) Per test piece a microsection shall be taken from the weld subjected to a cupping test. The photographs shall generally have a magnification of 200 (if required, other magnifications are possible).

   ag) For austenitic welded joints the base metal, heat affected zone and the deposited weld metal shall be examined for resistance to intergranular corrosion to DIN EN ISO 3651-2 with previous sensitization (1/2 h at 650 °C).

   ah) Chemical composition of all-weld metal where filler metals are used.

b) Clamp weld and circumferential weld between bellows and welding end.

   The clamp weld procedure qualification shall be adapted to the course of fabrication. A girth weld (welded all-round) shall be welded. The following tests shall be performed.

   ba) a penetrant testing to **Annex C** and assessment to AD 2000-Merkblatt HP 5/3,

   bb) a radiographic testing (only of the circumferential weld between bellows and welding end); performance to Section A 8.2; for the evaluation of the test results the requirements of acceptance level 1 to DIN EN ISO 10675-1 apply.

bc) one macrosection and one microsection each shall be taken from each test piece. The following examinations shall be made:
- macrosection (photographic general exposure)
- microsection (photographic exposure with 250 times magnification, if required other magnifications are also possible)

bd) In the case of austenitic welded joints the base metal, heat affected zone and the deposited weld metal shall be examined for resistance to intergranular corrosion to DIN EN ISO 3651-2 with previous sensitisation (1/2 h at 650 °C).

A 7.4 Production control tests

(1) During the welding of bellows longitudinal joints a test piece shall be welded for each welding process used and in the case of change of fabrication conditions (e.g. change in machine setting, insertion of a new strip, interruption of production). This test piece shall be examined with respect to the ductility of the bellows longitudinal joints by means of a suitable test procedure (e.g. cupping test, drift expanded specimen) that has been qualified within the qualification procedure and has been specified by agreement with the authorized inspector.

Note:

The following is not considered an „interruption of the production“

a) the insertion of new bushes for the welding of cylindrical bellows,

b) regular breaks within a shift,

c) change of shifts.

(2) One production control test per lot of delivery shall be performed. The tests shall be performed in accordance with Section A 7.3 in which case only one test is required for the tests as per subclause 2 ab, ac and ae.

A 7.5 Forming

A 7.5.1 Procedure qualification for forming

(1) For hot and cold forming the material and DIN standards, Stahl-Eisen and VdTÜV material sheets as well as AD 2000-Merkblatt HP 7/1 shall be considered.

(2) The forming procedure qualification shall be adapted to the forming process used, the type of product, the wall thickness, and the heat treatment condition. In the case of cold formed bellows the required calibration of the bellows shall be covered by the forming procedure qualification. The forming procedure qualification shall be performed in the presence of the authorized inspector. The following tests and checks shall be performed:

a) determination of the mechanical properties and penetrant testing of the starting plate (this is not required if the values and test results can be read from the acceptance test certificate for this starting plate),

b) determination of the maximum rate of forming,

c) penetrant testing to **Annex C** of the formed test piece where practicable; indications are not permitted,

d) dimensional check,

e) examination of the mechanical properties after forming, especially at locations of maximum rate of forming and on the bellows longitudinal joint.

(3) A report shall be established on the forming procedure qualification to contain all process details, the test results and the limits of application. The authorized inspector shall comment on this report in writing within 6 weeks. The period of validity of the forming procedure qualification shall be two years and will be extended automatically by another two years if work is done within its scope.

A 7.5.2 Heat treatment after forming

Heat treatment of the bellows upon cold forming is not required if the forming procedure qualification has shown that a heat treatment can be waived. Hot formed bellows shall be solution-annealed.

A 7.6 Identification marking and its conservation.

Upon completion of all tests and examinations to Section A 8 and the final inspection the authorized inspector shall check the identification marking of each bellows expansion joint, which shall contain:

a) the design pressure,

b) the direction of pressure application,

c) the design temperature,

d) the year built,

e) the serial number,

f) the name or identification of the manufacturer,

g) the certification stamp of the authorized inspector.

A 7.7 Cleaning and surface protection

A 7.7.1 Austenitic material

(1) Discolourations on welds are permitted if they meet the requirements of DIN 25410.

(2) The bellows expansion joints shall be cleaned and checked for freedom of fat, oil or cleansing agent residues. Hot formed bellows shall be descaled by abrasives suited for austenitic materials. The cleanliness level 2 to DIN 25410 shall be adhered to.

A 7.7.2 Ferritic materials

Ferritic materials of bellows expansion joints shall be cleaned and checked for fat, oils and cleansing agent residues. The surface protection layers shall not impair the performance of in-service inspections.

A 8 Inspection and testing

A 8.1 General

For final inspections on bellows expansion joints the requirements of KTA 3211.3 apply. Differing here from, clauses A 8.2 to 8.5 apply to the inspection and testing of bellows, and clauses A 8.6 and A 8.7 to the inspection and testing of bellows expansion joints.

A 8.2 Radiographic testing

A 8.2.1 Performance

(1) The testing shall basically be performed to DIN EN ISO 17636-1. The requirements of class B to DIN EN ISO 17636-1 shall be met. The substitute solution of Section 5 of DIN EN ISO 17636-1 shall not be applied in this case.

(2) The image quality values of image quality class B to DIN EN ISO 19232-3 shall be adhered to in which case the image quality indicators to DIN EN ISO 19232-1 shall be used.

(3) The adjacent base metal areas on both sides of the weld shall be radiographed on a width equal to or greater than 10 mm.

(4) In the case of circumferential welds a central radiograph shall be made provided the welds are accessible and the requirements of (1) to (3) are met.

(5) In the test X-ray tubes shall be used unless an at least equivalent evaluation is possible by the use of other radiation sources. Film/screen combinations with an as high as possible resolution and preferably vacuum cassettes shall be used.

A 8.2.2 Extent of testing and assessment

(1) Each bellows shall be subjected to a radiographic testing.

a) Extent of testing for bellows 100 %:

  aa) bellows longitudinal joints in unformed condition,

  ab) bellows attachment welds in the case of butt welds (**Figure A 4-1**, design type 1),

b) Assessment:
The requirements of acceptance level 1 to DIN EN ISO 10675-1 apply.

(2) The films shall be submitted to the authorized inspector for assessment.

A 8.3 Surface inspection

A 8.3.1 Performance

The surface inspection shall be performed to **Annex C**.

A 8.3.2 Extent of testing and assessment

Each bellows shall be subjected to a surface inspection in the presence of the authorized inspector.

a) Extent of testing

  aa) bellows welds upon forming, where accessible,

  ab) bellows attachment welds: 100 %.

  In the case of bellows expansion joints with butt welds (**Figure A 4-1**, design type 1) at diameters up to and including DN 300 the inspection shall be performed from the outside, and with butt welds at diameters greater DN 300 from the outside and the inside.

  ac) other welds to clause A 4.3.3: 100 %.

b) Assessment: for longitudinal and circumferential welds no indications are permitted. Other welds to clause A 4.3.3 shall be assessed in accordance with AD 2000-Merkblatt HP 5/3.

A 8.4 Visual inspection and dimensional check

The following shall be checked by the manufacturer

a) the correct dimensions of the bellows and the correct number of convolutions,

b) the bellows surfaces for damage,

c) the cleanliness to DIN 25410.

A 8.5 Materials testing

(1) In the case of hot formed bellows with solution annealing upon hot forming, the following tests shall be performed per melt and heat treatment batch and be proved to the authorized inspector.

a) 1 tensile test to DIN EN ISO 6892-1 (certificate to DIN EN 10204 - 3.2)

b) 1 test for resistance to intergranular corrosion to DIN EN ISO 3651-2 with previous sensitization (1/2 h at 650 °C) (certificate to DIN EN 10204 - 3.1)

(2) The specimens shall be taken from the bellows excess length annealed upon reverse deformation or from unformed test pieces annealed along with the bellows.

A 8.6 Pressure testing

The bellows expansion joints shall be subjected to a pressure test with 1.3 times their design pressure at the manufacturer's works and in the presence of the authorized inspector. In the case of externally pressurized bellows expansion joints, an external pressure test with 1.5 times the design pressure of the reactor containment vessel shall be performed. The pressure test shall be performed at the maximum deflection or rotation of the bellows expansion joint that is required at specified operation. Here, the lateral deflection may be considered by the respective axial movement. After the pressure test the bellows expansion joint shall be completely dried and checked for cleanliness.

A 8.7 Leak testing

(1) The bellows expansion joint shall be completely dried and checked for cleanliness. Following this check, the gas leak tightness shall be proved at the manufacturer's works in the presence of the authorized inspector.

(2) A leak rate relating to helium of up to 10^{-4} Pa · m^3 · s^{-1} is permitted.

Annex B

Requirements for components of individual part group EG 2 and for components of design loading level R3

Contents

B 1 Application

(1) Annex B shall be applied to materials and types of products, documents and documentation as well as to the manufacture of components

a) for the pressure-retaining wall of components of part group EG 1 of design loading level R3,

b) of part group EG 2,

c) of integral support structures of design loading level R3 and

d) plane load-bearing structures of non-integral support structures.

(2) The classification of components shall be taken from **Table 4-1**.

B 2 Materials and types of products

B 2.1 General

B 2.1.1 Selection of materials

(1) **Table B 2-1** shows the allowable materials.

(2) The materials shall be suited for the intended use with respect to their properties.

(3) The use of other materials than given by **Table B 2-1** shall be subject to agreement by the authorized inspector.

B 2.1.2 Requirements to be met by the manufacturer

(1) AD 2000-Merkblatt W 0 covers the requirements to be met by the manufacturer.

(2) As regards the requirements for test supervisory personnel and operators for non-destructive testing, the requirements of KTA 3211.1, clause 11.1.4 apply.

Type of material	Allowable materials
(1) Ferritic materials	a) materials of material groups WI and WII to KTA 3211.1 b) materials to test group 1 to AD 2000-Merkblatt HP 0 In the case of carbon or low-alloy ferritic steels only the killed steel qualities are permitted. c) materials 10CrMo9-10 (1.7380), 13CrMo4-5 (1.7335), only in the case of special operational loadings (e.g. wear, corrosion, erosion) by agreement with the authorized inspector
(2) Austenitic materials	a) stabilized austenitic steels X6CrNiTi18-10 (1.4541) X6CrNiNb18-10 (1.4550) X6CrNiMoTi17-12-2 (1.4571) X6CrNiMoNb17-12-2 (1.4580) b) non-stabilized steels X2CrNiMoN17-13-5 (1.4439)

Table B 2-1: Allowable materials

B 2.2 Requirements for materials

B 2.2.1 General requirements

The requirements of the AD 2000-Merkblätter series W apply.

B 2.2.2 Special requirements for ferritic materials

B 2.2.2.1 Analysis

(1) Where the phosphor or sulphur content of certain materials is not specified with tighter restrictions, the following limit

values shall be adhered to by plates, pipes and forgings made from allowable materials to **Table B 2-1**, line (1):

P ≤ 0.035 %, S ≤ 0.030 %.

Note:
The heat may be selected freely.

(2) This limitation of analysis values does not apply in the case of:

a) minor dimensions (≤ DN 80 or s ≤ 10 mm),
b) utilization of the allowable stress of loading level B to **Table 6-1** smaller than or equal to 50 %,
c) standardized parts to DIN standards (e.g. standard flanges),
d) series-production parts by agreement with the authorized inspector,
e) unwelded components,
f) qualification tested components.

B 2.2.2.2 Plates with improved properties for loading vertical to the product surface

Where plates with a thickness greater than 20 mm are loaded vertically to the product surface (e.g. anchor plates), the improved properties in thickness direction to DIN EN 10164, quality class Z 25 shall be adhered to.

B 2.3 Non-destructive tests and examinations of product forms

(1) The non-destructive tests and examinations to be performed on product forms shall be read from **Table B 2-2**.

(2) In the case of percentage or random tests, the test parties involved shall only confirm those tests and inspections which were performed by them. The respective extent of testing and the examined area (e.g. location, test length, test sections, etc.) shall be clearly indicated in the test record or test and inspection sequence plan.

B 2.4 Proof of quality

(1) The proof of quality shall be made in accordance with the AD 2000-Merkblätter of the W series. Supplements required with respect to the material and shape of product shall be specified with the authorized inspector.

(2) The results of the non-destructive examination shall be certified by the manufacturer with acceptance test certificate 3.1 to DIN EN 10204.

Product form	Test procedures, extent of testing and acceptance criteria		
	Ultrasonic testing	Surface inspection 1)	Radiographic testing 2) or eddy-current testing
Plates s > 10 mm for anchor plates	Edge zone scanning The requirements of quality class E_3 a) to DIN EN 10160 shall be met in the case of plates made of ferritic steels b) to DIN EN 10307 shall be met in the case of plates made of austenitic steels	—	—
Pressed and dished parts	—	Half pipes, flange edge and knuckle of heads 3) 100 % For the assessment the following criteria apply: indications that are deemed to be attributable to planar flaws are not permitted. Isolated pores are permitted.	—
Pipes (seamless)	Ferrite: testing for longitudinal defects to DIN EN ISO 10893-10, acceptance class U2, subclass C Austenite: testing to AD 2000-Merkblatt W2	—	Alternatively to ultrasonic testing for s ≤ 6 mm: eddy-current testing to DIN EN ISO 10893-2, acceptance class E1H
Pipes (longitudinally welded)	a) Pipes to DIN EN 10217-2 and pipes to DIN EN 10217-5, test category 1 in each standard: The welds of all pipes shall be tested for longitudinal defects to DIN EN ISO 10893-11, acceptance class U3, “N”-type notch at the inside and at the outside. b) Pipes to DIN EN 10217-2 test category 2: All pipes shall be tested for longitudinal defects to DIN EN ISO 10893-10, acceptance class U2, subclass C, “N”-type notch at the inside and at the outside. c) Pipes to DIN EN 10217-5 test category 2: The welds of all pipes shall be tested for longitudinal defects to DIN EN ISO 10893-11, acceptance class U3, “N”-type notch at the inside and at the outside, and a test for laminar-type discontinuities shall be performed on the entire base material to DIN EN ISO 10893-8 as well as on the pipe ends and the plate or strip edges adjacent to the weld to DIN EN ISO 10893-9, acceptance class U2 for both standards. d) Austenite for nominal wall thicknesses s > 40 mm: to AD 2000-Merkblatt W2	CrMo steels: 100 % of the welds Other steels: spot checks For the assessment the following criteria apply: for magnetic particle testing the acceptance criteria to DIN EN ISO 10893-5, acceptance class M1, and for penetrant testing the acceptance criteria to DIN EN ISO 10893-4, acceptance class P1.	Austenite with nominal wall thicknesses s ≤ 40 mm: 100 % of the welds a) s > 6 mm: Radiographic testing For the assessment the acceptance criteria to DIN EN ISO 10893-6 apply. b) s ≤ 6 mm: Eddy-current testing to DIN EN ISO 10893-2, acceptance class E1H

Table B 2-2: Non-destructive testing of product forms (continued on next page)

Product form	Test procedures, extent of testing and acceptance criteria		
	Ultrasonic testing	Surface inspection 1)	Radiographic testing 2) or eddy-current testing
Reducers, pipe bends (seamless)	—	10 % Indications that are deemed to be attributable to planar flaws are not permitted. Isolated pores are permitted.	—
Reducers, pipe bends (longitudinally welded)	Ferrite: s ≤ 20 mm: 100 % testing to AD 2000-Merkblatt HP 5/3 test class B s > 20 mm: 100 % testing to AD 2000-Merkblatt HP 5/3 test class C Where ≤ 85 % of the nominal operating stress are utilized: 10 %	CrMo steels: 100 % of the welds Other steels: spot checks For the assessment the following criteria apply: for magnetic particle testing the acceptance criteria to DIN EN ISO 10893-5, acceptance class M1, and for penetrant testing the acceptance criteria to DIN EN ISO 10893-4, acceptance class P1.	Ferrite: s ≤ 20 mm: 100 % radiographic testing alternatively to ultrasonic testing Austenite: 100 % radiographic testing For the assessment the acceptance criteria to DIN EN ISO 10893-6 apply. Where ≤ 85 % of the nominal operating stress are utilized: 10 %
Forgings	a) 100 % of hollow parts with wall thicknesses s ≤ 30 mm shall be tested for longitudinal and transverse defects to DIN EN ISO 10893-10, acceptance class U2, subclass C b) all other forgings ba) Ferrite: to DIN EN 10228-3 (100 % scanning coverage to Tables 3 and 4, quality class 3) bb) Austenite: to DIN EN 10228-4 (100 % scanning coverage to Tables 2 and 3, quality class 2)	in finished condition, where the part weight > 300 kg For the assessment the following criteria apply: for magnetic particle testing the acceptance criteria to DIN EN 10228-1, quality class 4, and for penetrant testing the acceptance criteria to DIN EN 10228-2, quality class 4.	—

1) Performance: to **Annex C**. On sufficiently magnetizable materials magnetic particle testing shall be performed.
2) Performance: to clause A 8.2.1.
3) Omitted for cold-formed components without heat treatment after cold-forming.

Table B 2-2: Non-destructive testing of product forms (continued)

B 3 Documents, documentation

B 3.1 Documents for design, calculation and manufacture

(1) Where applicable to the respective pipe penetration, the manufacturing documents listed in **Table B 3-1** shall be established and checked by the manufacturer.

(2) Where applicable to the respective pipe penetration, the following documents shall be examined by the authorized inspector within the design approval procedure:

a) design data,
b) assembly drawing,
c) parts list with data on materials,
d) component drawings of piping components,
e) dimensioning,
f) analysis of mechanical behaviour,
g) test and examination sequence plan,
h) welding procedure sheet,
i) repair plans.

B 3.2 Documentation

The documentation of the documents listed in **Table B 3-1** shall be made in accordance with KTA 3211.3.

B 4 Manufacture

B 4.1 Requirements for manufacture

(1) The requirements of AD 2000-Merkblatt HP 0 apply with respect to the manufacturer's qualification.

(2) As regards the requirements for test supervisory personnel and operators for non-destructive testing, the requirements of KTA 3211.3, clause 3.3.4 apply.

B 4.2 Welding

B 4.2.1 Weld preparation

B 4.2.1.1 Dressing of fusion faces

(1) Fusion faces shall preferably be machined.

(2) Where fusion faces are made by thermal cutting, ferritic materials shall be preheated in the following cases:

a) at an ambient temperature less than 5 °C
b) where required by the material (e.g. rules, guidelines).

(3) Thermally cut fusion faces shall comply with DIN EN ISO 9013 as regards the perpendicularity and angularity tolerances which shall be at least within range 4, and as regards the mean height of the profile Rz which shall be at least within range 2. In the case of ferritic materials the fusion faces shall be dressed to be scale-free. Unless proved otherwise in the procedure qualification, the surface shall be machined by 2 mm in the case of ferritic materials with $R_{p0.2\,RT}$ exceeding 370 N/mm^2 and other materials to **Table B 2-1** (1) c).

(4) Fusion faces made by plasma cutting of austenitic materials may remain undressed.

(5) Fusion faces shall be free from contaminations (e.g. rust, fat, paint).

Documents on design, manufacture and documentation		Document type
1	Design	
1.1	Design data (e.g. in the form of a design data sheet)	E
1.2	Assembly drawing (where required, component group drawing)	E
1.3	Parts list with data on materials (or separate list of materials or drawing)	E
1.4	Component drawings of piping components	E
2	Calculation	
2.1	Dimensioning	E
2.2	Analysis of mechanical behaviour	E
2.3	Isometric drawings for calculation	E
3	Manufacture	
3.1	General requirements (assessment of manufacturer, welder´s qualification record, welding procedure qualification)	Z
3.2	Detail drawings	Z
3.3	Isometric drawings for fabrication (pipework)	E
3.4	Parts list with reference to isometric drawings (pipework)	E
3.5	Materials certificates	E
3.6	Control plan of manufacturer	Z
3.7	Manufacturing instructions	Z
3.8	Test and examination sequence plan or equivalent testing and inspection schedule	E
3.9	Welding procedure sheets and heat treatment plan	E
3.10	Repair plans (test and examination sequence plan with welding procedure sheets)	E
3.11	Films and film location plans (RT)	E
3.12	Test report UT, RT, MT/PT, ET, LT	E
3.13	Dimensional survey sheets (intermediate checks)	Z
3.14	Reports on welding procedure qualifications	Z
3.15	Reports on component-related production control tests	E
3.16	Dimensional check of finished components	E
3.17	Non-conformance reports	E
3.18	Total documentation, quality approval release certificate	E
E = Final file Z = Intermediate file		

Table B 3-1: Documents on the design, manufacture and documentation of components

B 4.2.1.2 Tolerances

Within the area of single-side circumferential welds the internal diameter tolerances shall be determined such that a root weld meeting the requirements is obtained and the allowable misalignment to clause B 4.2.3.2 is not exceeded.

B 4.2.2 Performance of welding work

B 4.2.2.1 Environmental conditions

The welding work shall be done under weatherproof conditions. In the case of ambient temperatures of less than 5 °C, special precautions shall be taken with respect to the materials used.

B 4.2.2.2 Welding conditions

(1) The welding conditions for ferritic materials (preheat temperature, heat input, build-up of layers) shall be fixed such that there is an as little as possible hardness increase in the heat affected zone. A hardness value of 350 HV 10 shall normally not be exceeded.

(2) For the heat input during welding (preheating, interpass temperature or soaking) the requirements for the respective material apply. The required preheat temperature shall be adhered to in the area 4 times the wall thickness “s” on both sides of the weld (for s smaller than 25 mm, 100 mm will suffice).

(3) The weld area shall be free from condensed water.

B 4.2.2.3 Build-up of layers

(1) All connecting welds shall basically be multi-layer welded.

(2) The temper bead technique shall be used for the following materials,

a) P355NH (1.0565) and 15MnNi6-3 (1.6210) (if no stress relieving is performed after welding),
b) materials with $R_{0.2\ RT}$ exceeding 370 N/mm^2.

(3) The following processes to apply the temper bead technique are permitted:

a) The layer build-up sequence should start from the fusion faces. The last beads of the cover pass shall not fuse the base metal. They can be integrated in the build-up of layers.
b) A deviating sequence of layer build-up is permitted (e.g. weave beads for vertical welds) if its equivalence is proved within a procedure qualification with respect to the temper bead effect.

(4) In the case of austenitic materials the layers shall be built up by stringer beads (with an as little as possible heat input).

B 4.2.2.4 Attachment welds

(1) Single-bevel and double-bevel groove welds and fillet welds shall be welded with at least two layers. The last bead shall not fuse the base metal of the pressure-retaining wall. In the case of stringer beads this requirement does not apply.

(2) Fillet weld ends shall be welded over.

B 4.2.2.5 Welding of root pass

When welding the root pass of austenitic single-side welds, the root side shall be shielded (e.g. by forming gas) unless the root is dressed mechanically after welding. The root of ferritic welds shall be dressed if this is required to make ultrasonic testing (scanning from one weld side) possible.

B 4.2.2.6 Root gouging

(1) Root gouging prior to depositing backing runs should preferably be done by machining. For ferritic materials flame gouging or gouging with copper-metallized carbon electrodes is permitted. With respect to preheating, surface quality and cleanliness, the requirements of B 4.2.1.1 apply.

(2) Root gouging may be omitted if an oxidation protection is provided and this is proved accordingly in the procedure qualification.

B 4.2.2.7 Repair welding

The requirements of clauses B 4.2.2.1 to B 4.2.2.6 apply where applicable, also to the dressing of defects and for the performance of repair welding.

B 4.2.2.8 Tack welds and temporary weld attachments

The above requirements also apply to tack welds and temporary weld attachments. Tack welds may remain as part of the root (partial root) if the length of the tack weld (generally exceeding 50 mm) is adequately dimensioned.

B 4.2.2.9 Arc striking

Arc striking of electrodes outside the weld groove is not permitted. If, however, arc striking occurs outside the weld groove, they shall be ground and subjected to surface inspection according to **Annex C**. Crack-like surface defects are not permitted. Weld spatter shall be removed.

B 4.2.3 Requirements as to the quality of welds

B 4.2.3.1 Mechanical properties

The mechanical properties shall meet the requirements for the base metal. This shall be proved by the results obtained by the procedure qualification and production control test.

B 4.2.3.2 Internal and external irregularities

In addition to the requirements of AD 2000-Merkblatt HP 5/1 a maximum of 2 mm applies for the misalignment of pipe circumferential welds 0.15 · s.

B 4.2.3.3 Discolouration of austenitic material

Discolouration on welds is permitted if it complies with the specifications of DIN 25410.

B 4.2.3.4 Corrosion resistance

Austenitic surface metal overlays shall be corrosion-resistant in the finished condition at a distance of 2 mm or greater under the surface. (To be proved in the procedure qualification and production control test).

B 4.2.3.5 Underflushing

Underflushing (excessive dressing) shall basically be avoided. Local underflushing equal to or smaller than 5 % below the design wall thickness is permitted without further proof if the transitions (to be flat with an angle smaller than or equal to 5°) and surface waviness permit the required destructive examination to be performed.

B 4.3 Welding filler metals and consumables

Only filler metals and consumables qualified to VdTÜV-Merkblatt Schweißtechnik 1153 shall be used.

B 4.4 Welding procedure qualification

B 4.4.1 General

(1) For the materials to be welded valid procedure qualifications shall be submitted prior to starting the welding work. Unless other or further stipulations are laid down in this section, AD 2000-Merkblatt HP 2/1 shall apply. Alternatively, advance production control tests are permitted within the procedure qualification.

(2) Where AD 2000-Merkblatt HP 2/1 does not lay down requirements for the performance and evaluation of procedure qualification, agreements shall be made with the authorized inspector.

(3) A procedure qualification for butt welds covers attachment welds within the scope of that procedure qualification.

B 4.4.2 Performance

(1) For new test pieces on plates the weld shall be welded parallel to the main direction of plate forming.

(2) The heat treatments required for the component shall be covered.

(3) There need not be equivalence of melts between the materials, filler metals and consumables used for the procedure qualification and the components.

(4) A valid procedure qualification shall be available for the repair welding procedure.

B 4.4.3 Extent of testing and requirements

The extent of testing and requirements laid down by AD 2000-Merkblatt HP 2/1 apply. In addition, the following applies:

a) Mechanical properties

   For the heat affected zone, the minimum requirements for the base metal apply with respect to the impact energy.

b) Pipe circumferential welds

   Where mechanised welding procedures with orbital welding equipment are used, special requirements apply upon agreement with the authorized inspector.

c) Austenitic welds

   Proof of resistance to intergranular corrosion to DIN EN ISO 3651-2 with previous sensitisation (1/2 h at 650 °C)

d) Combined welds between austenitic and ferritic materials.

   For the testing of the heat affected zone, the extent and requirements for testing of each weld side shall apply with respect to the materials used. A proof of resistance to intergranular corrosion and a determination of the delta ferrite content are not required.

Differing from AD 2000-Merkblatt HP 2/1 the following applies:

a) Deposition welding

   Surface inspection to **Annex C**, proof of strength and ductility (bending tests), macro/micro sections and hardness test are required. (For austenitic material additionally a proof of resistance to intergranular corrosion for a thickness of 2 mm and more underneath the finished surface as well as a determination of the delta ferrite content are required.)

b) Load-transferring deposited welds

   The procedure qualification for a welded joint basically covers load-transferring deposited welds. Special requirements are e.g. required in the case of mechanised welding processes if essential differences in heat dissipation exist regarding the welded joints. In individual cases (e.g. mechanised processes) the requirements shall be specified with the authorized inspector.

B 4.4.4 Test report

Upon completion of the welding procedure qualification, a test report shall be established to cover all details on the performance of the procedure qualification and all test results.

B 4.5 Production control tests

B 4.5.1 General

During fabrication, the manufacturer shall prove by means of production control tests that the welds meet the requirements. Unless no other or more detailed requirements are laid down by this section, AD 2000-Merkblatt HP 5/2 shall apply.

B 4.5.2 Performance

(1) The number of the test pieces to be welded is laid down in AD 2000-Merkblatt HP 5/2.

(2) For welds for which no stipulations are laid down by AD 2000-Merkblatt HP 5/2 (e.g. for piping), a production control test shall be performed once a year.

(3) There need not be equivalence of melts between the materials, filer metals and consumables used for the production control test and the components.

B 4.5.3 Extent of testing and requirements

(1) The extent of testing and requirements for production control tests are laid down in AD 2000-Merkblatt HP 5/2.

(2) The stipulations of clause B 4.4.3 apply additionally to AD 2000-Merkblatt HP 5/2.

B 4.5.4 Test report

Upon completion of the production control test, a test report shall be established to cover all details on the performance of the production control test and all test results.

B 4.6 Forming of components

B 4.6.1 Procedures

Only qualified procedures are permitted for the forming of components. The type and extent of procedure qualifications for bends shall comply with KTA 3211.3.

B 4.6.2 Cold forming

(1) During cold forming a repeated acceptance of materials is not required if the permitted degrees of cold forming mentioned in AD 2000-Merkblätter HP 7/2 and HP 7/3 are not exceeded.

(2) Where the permitted degree of cold forming is exceeded during cold forming, a heat treatment and testing of the material to include non-destructive testing to section B 2 is basically required. Where welds are also to be cold formed, special procedure qualifications are required. Where a heat treatment generally to be applied after cold forming can be omitted, this shall be proved to be permissible. This proof shall also consider the influence on the corrosion resistance.

B 4.6.3 Hot forming

(1) The conditions laid down for the specific material shall be satisfied (e.g. VdTÜV material sheets, AD 2000-Merkblätter HP 7/2, HP 7/3 and HP 8/2).

(2) Where welded parts are hot formed it shall be proved that the weld metal also meets the same requirements after forming. Otherwise, the hot formed weld metal shall be removed and the part be welded anew.

B 4.6.4 Record

The manufacturer shall establish a record on the forming work performed to contain data on:

a) heat treating and forming facilities,

b) degree of forming (unless a heat treatment is performed),

c) temperature control.

B 4.6.5 Acceptance of formed components

(1) On hot formed components or components with heat treatment after forming a material test including a non-destructive testing shall be performed to comply with the requirements for the respective product types to Section B 2.

(2) Testing on a simulated formed test piece is permitted if testing on the component is not possible.

B 4.6.6 Tolerances for pipe bends and bent pipes

(1) The out-of-roundness shall not exceed 5 % (on welds it shall be smaller than or equal to 2 %).

(2) The waviness shall be specified during the appraisal.

(3) The requirements for dimensions, bending angle and changes in wall thickness shall be specified in dependence of the bending method used.

B 4.7 Heat treatment

B 4.7.1 General

Heat treatments shall basically be performed to comply with the requirements of AD 2000-Merkblätter HP 7/1, HP 7/2 and HP 7/3.

B 4.7.2 Post-weld heat treatment

Upon final heat treatment, no welding work shall be performed on components requiring annealing after welding due to their wall thickness.

B 4.7.3 Local stress relief treatment

B 4.7.3.1 Annealing area

(1) For circumferential welds the width of the annealing area shall be at least 2 · s (for greater than DN 100 at least 100 mm).

(2) The temperature pattern is shown in **Figure B 4-1**.

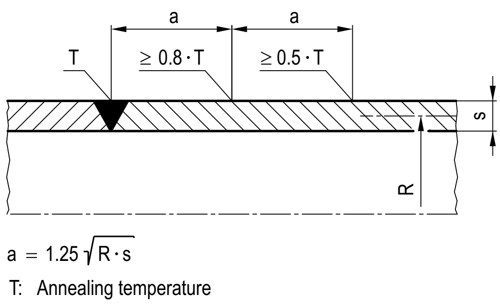


Figure B 4-1: Temperature pattern during stress relieving

(3) For wall thicknesses s smaller than or equal to 30 mm the temperature profile requirement is met if the heat input is provided to cover an area of 8 · s and sufficient insulation beyond this width is provided.

(4) The heat input, insulation, heating and cooling rates shall be fixed such that damage to the component or materials is avoided.

B 4.7.3.2 Restraint to thermal expansion

In the case of thermal restraint or geometric discontinuities, special measures shall be taken (insulation, low heat-up rate, larger heat treatment area) to avoid inadmissible permanent deformation. Proof can be given by means of calculations made or values obtained from trials or experience gained.

B 4.7.3.3 Procedures

(1) The welding procedure sheet (or in special cases, the heat treatment plan) shall lay down the required data on heat

treatment equipment, insulation, heat input, and temperature control.

(2) Where a procedure qualification is available, simple references (with reference to the qualification) are permitted.

B 4.7.4 Certificates

The certificates shall be established to AD 2000-Merkblatt HP 7/1, Section 3.

B 4.8 Identification marking

(1) The components shall be clearly identified.

(2) Where products are cut to form several parts, the identification marking shall be transferred by authorized persons.

(3) Such identification markings are permitted as do not damage the part or induce pronounced notch effects. (The dependence on the wall thickness shall be considered.) For small parts and series-production parts of minor dimensions, organisational measures are permitted. Encodement is permitted.

(4) The location of welds shall be clearly marked. For volumetric non-destructive testing the point of origin and main direction (counting direction) shall be indicated. The identification system shall be laid down in writing.

B 4.9 Tolerances

Where the manufacturing documents do not contain data on tolerances, the following tolerances (e.g. for linear and angular dimensions) apply:

a) to DIN ISO 2768-1, tolerance class „coarse“ for unmachined parts,

b) to DIN ISO 2768-1, tolerance class „medium“ for machined parts.

B 4.10 Manufacturing supervision and final inspection

B 4.10.1 In-process inspection by the manufacturer.

(1) The essential steps of an in-process inspection shall be laid down in a check list. Examples are (if applicable)

a) review of manufacturing preconditions,

b) visual inspection, dimensional check,

c) intermediate non-destructive tests,

d) control of essential processing facilities,

e) assembly,

f) control of welding work (preheating, welding characteristic data, utilization of welding consumables, thermal cutting),

g) control that defects have been removed,

h) check of cleanliness,

i) preservation, packing,

j) control of fabrication-accompanying documents.

B 4.10.2 Fabrication supervision by the authorized inspector

The fabrication supervision shall be made randomly at fabrication stages to be fixed by the authorized inspector.

B 4.10.3 Final inspection by the manufacturer

(1) The essential final inspections to be performed by the manufacturer shall be listed in a test and examination sequence plan. Examples are:

a) review of manufacturing preconditions, availability of material certificates, procedure qualifications,

b) check of essential dimensions (including misalignment and tolerances),

c) heat treatment,

d) non-destructive tests,

e) pressure and leak tests,

f) identification, transfer of identification markings,

g) summarized statement on the performance of in-process inspections by the manufacturer and the fabrication supervision by the authorized inspector.

B 4.10.4 Final inspections by the authorized inspector

The final inspections shall generally be performed at fabrication stages randomly fixed by the authorized inspector.

B 4.11 Non-destructive testing on welds

(1) The extent of non-destructive testing on welds shall be read from **Table B 4-1**. The percentage data apply per welder employed.

(2) For the performance of the tests the following applies:

a) Ultrasonic testing shall be performed to AD 2000-Merkblatt HP 5/3, test class B.

b) Radiographic testing shall be performed to clause A 8.2.1.

c) Surface inspection by magnetic particle or penetrant testing shall be performed to **Annex C**, whereby magnetic particle testing shall preferably be used on sufficiently magnetizable materials.

(3) The evaluation of the test results shall comply with AD 2000-Merkblatt HP 5/3.

Materials	Ferrite $R_{p0.2\,RT}$ > 370 N/mm²		Ferrite $R_{p0.2\,RT} \leq 370$ N/mm² Austenite and combinations of austenitic/ferritic materials	
Non-destructive testing methods	RT [1] or UT	MT/PT	RT or UT [2]	MT/PT
Examination of welds	25 % [3]	25 %	5 % [3]	Spot Checks

RT : Radiography
UT : Ultrasonic testing
MT : magnetic particle testing
PT : penetrant testing

[1] Double-wall technique permitted up to a thickness of the radiographed wall w ≤ 40 mm.

[2] Not to be applied for austenite and combinations of austenitic/ferritic materials.

[3] Not to be tested are
a) nozzle welds ≤ DN 25,
b) attachment welds (singe-bevel, double-bevel groove welds, fillet welds) with a wall thickness s < 15 mm of the attaching component.

Table B 4-1: Extent of non-destructive examination on welded joints

Annex C

Performance of surface inspections by magnetic particle and penetrant methods

Contents

C 1 General requirements

C 1.1 Surface condition

(1) The surfaces to be inspected shall show a condition suitable for testing.

(2) They shall be free from scale, weld spatter or other disturbing impurities.

(3) Grooves and notches affecting the test result shall be removed.

C 1.2 Viewing conditions

(1) The viewing conditions of DIN EN ISO 3059 shall be observed. In addition, the requirements as per (2) to (5) shall be met:

(2) The eyes of the operator shall have at least 5 minutes to adapt to the light conditions.

(3) For the purpose of better detectability of defects sufficient contrast shall be provided in magnetic particle testing by the use of suitable media (e.g. fluorescent detection media or application of a thin colour coat only slightly covering the underground). Ultraviolet radiation of type UVA may additionally be used to improve the contrast in penetrant testing using fluorescent penetrants.

(4) During the inspection the angle of viewing shall not deviate by more than 30 degrees from the surface normal. During viewing the distance to the examination surface shall normally be approximately 300 mm.

(5) For the inspection auxiliary means (e.g. magnifying glasses, contrast-improving spectacles, mirrors) are permitted.

C 1.3 Post-cleaning

Upon completion of inspection, the parts shall be properly cleaned to remove residues from the test fluid.

C 2 Magnetic particle testing

C 2.1 Methods and performance of testing

Magnetic particle testing shall be performed to DIN EN ISO 9934-1 to meet the following requirements.

C 2.1.1 Methods

(1) Where magnetisation is achieved in partial areas by current flow technique or yoke magnetisation, AC magnetisation shall normally be used.

(2) The DC magnetisation method shall only be used upon agreement by the authorized inspector.

(3) The residual magnetic field strength shall not exceed 800 A/m unless a lower value is required for the fabrication. Where the specified value is exceeded, the part shall be demagnetised and the value of the residual magnetic field strength be recorded.

(4) For the magnetic particle testing techniques the following identifying characters shall be used:

Magnetic particle testing technique		Characters
Yoke magnetization	with permanent magnet	JD
	with electromagnet	JE
Magnetization by current carrying-conductors	with coil	LS
	with other conductors (cable)	LK
Magnetization by current flow	self-induced current	SS
	induced current flow	SI

C 2.1.2 Contact areas in case of direct magnetisation

(1) Where the test is performed by current flow technique, consumable electrodes (e.g. lead fin alloys) shall be used, if possible. It shall be ensured that in the contact areas overheating of the material to be tested is avoided.

(2) Where overheating has occurred the overheated areas shall be marked, ground over after the test and be examined for surface cracks, preferably by magnetic particle testing using yoke magnetisation.

C 2.1.3 Direction of magnetisation

Each location on the surface shall be tested from two directions of magnetisation offset by approximately 90 degrees.

C 2.1.4 Magnetic field strength

(1) In the case of AC magnetisation the tangential field strength on the surface shall be at least 2 KA/m and shall not exceed 6.5 KA/m.

Note:

a) The required flux density in the test object surface of at least 1 T will be obtained in low-alloy or low-carbon steels with high relative permeability as early as at a tangential field strength of 2 kA/m.

b) For other steels with lower permeability a higher field strength may be required.

c) Where magnetisation is too high, structural indications (spurious indications) may cover relevant indications.

(2) It shall be checked by measurements that these values are adhered to or test conditions shall be determined under which these values may be obtained.

C 2.1.5 Magnetisation times

The following guide values apply with respect to the application of the magnetic particles and magnetisation:

a) Magnetisation and application: at least 3 seconds

b) Subsequent magnetisation: at least 5 seconds

C 2.2 Inspection medium

According to DIN EN ISO 9943-2 sample-tested media shall be used. Verification of such sample testing shall be submitted to the authorized inspector.

C 2.2.1 Wet particle inspection method

(1) Magnetic particles with an average grain size smaller than or equal to 8 µm shall be used. Depending on application, black, fluorescent or coloured powders may be used.

Note:

The required average grain diameter ensures comparability with periodic tests, see DIN 25435-2.

(2) Prior to bathing the surface care shall be taken to ensure that the magnetic powder is distributed uniformly in the vehicle fluid and is kept in suspension. Prior to and during testing the powder suspension shall be spot-checked by suitable pre-magnetised test units.

C 2.2.2 Dry particle method

(1) The dry particle method shall only be used for an intermediate test in warm condition.

(2) The device for applying the powder shall make possible such a fine spraying that no accumulations of powder occurs. It shall be ensured that the powders used do not agglomerate under the influence of the workpiece temperature.

C 2.3 Test instruments

The test instruments shall meet the requirements of DIN EN ISO 9934-3.

C 3 Penetrant testing

C 3.1 Testing system

(1) Colour contrast penetrants shall preferably be used. Fluorescent penetrants or fluorescent colour contrast penetrants may also be used.

(2) Solvents or water or both in combination may be used as penetrant remover.

(3) Only wet developers suspended in an aqueous solvent shall be used. Dry developers may only be applied on the testing surface by electrostatic charging.

(4) For the examination system at least sensitivity class „High Sensitivity“ to DIN EN ISO 3452-2 shall be adhered to.

(5) The suitability of the testing system (penetrant, solvent remover and developer) shall be demonstrated by means of a sample examination as to DIN EN ISO 3452-2. The results of the demonstration by sample testing shall be submitted to the authorized inspector.

(6) Penetrants in test equipment and partly used open tanks (except for aerosol cans) shall be monitored by the user with flux indicator 2 to DIN EN ISO 3452-3. In this test the maximum penetration and development times shall not exceed the minimum times specified for the evaluation. The testing sensitivity obtained shall be recorded.

C 3.2 Performance

(1) Penetrant testing shall be performed to DIN EN 571-1 to meet the following requirements.

(2) The penetration time shall be at least half an hour.

(3) Immediately after drying of the developer a first inspection shall normally be made. A further inspection should be made not earlier than half an hour after the first inspection has passed.

(4) Further inspection times are required if during the second inspection crack-like indications are detected which were not visible during the first inspection.

Note:

Further inspection times may also be suitable if during the second inspection significant changings or additional indications are detected.

(5) The evaluation shall be made in consideration of the results of all inspections.

Annex D

Regulations referred to in this Safety Standard

(The references exclusively refer to the version given in this annex. Quotations of regulations referred to therein refer to the version available when the individual reference below was established or issued).

AtG		Act on the Peaceful Utilization of Atomic Energy and the Protection against its Hazards (Atomic Energy Act) Atomic Energy Act in the version promulgated on July 15, 1985 (BGBl. I, p. 1565), most recently changed by article 1 of the act dated December 4, 2022 (BGBl. I, p. 2153)
StrSchG		Act on the Protection against the Harmful Effect of Ionising Radiation (Radiation Protection Act - StrlSchG) Radiation Protection Act of June 27, 2017 (BGBl. I, p. 1966), most recently changed by the promulgation of January 3, 2022 (BGBl. I, p. 15)
StrlSchV		Ordinance on the Protection against the Harmful Effects of Ionising Radiation (Radiation Protection Ordinance - StrlSchV) Radiation Protection Ordinance of November 29, 2018 (BGBl. I, p. 2034, 2036), most recently changed by article 1 of the ordinance dated October, 2021 (BGBl. I p. 4645)
SiAnf	(2015-03)	Safety Requirements for Nuclear Power Plants (SiAnf) of November 22, 2012, amended version of March 3, 2015 (BAnz AT 30.03.2015 B2), most recently changed as promulgated by BMUV on February 25, 2022 (BAnz AT 15.03.2022 B3)
Interpretions of SiAnf	(2015-03)	Interpretations of the safety requirements for nuclear power plants of November 22, 2012, of November 29, 2013 (BAnz AT 10.12.2013 B4), changed on March 3, 2015 (Banz AT of March 30, 2015 B3)
KTA 1408.1	(2017-11)	Quality Assurance for Weld Filler Materials and Welding Consumables for Pressure and Activity Retaining Systems in Nuclear Power Plants; Part 1: Qualification Testing
KTA 1408.2	(2017-11)	Quality Assurance for Weld Filler Materials and Welding Consumables for Pressure and Activity Retaining Systems in Nuclear Power Plants; Part 2: Manufacture
KTA 3201.1	(2017-11)	Components of the Reactor Coolant Pressure Boundary of Light Water Reactors; Part 1: Materials and Product Forms
KTA 3201.2	(2017-11)	Components of the Reactor Coolant Pressure Boundary of Light Water Reactors; Part 2: Design and Analysis
KTA 3201.3	(2017-11)	Components of the Reactor Coolant Pressure Boundary of Light Water Reactors; Part 3: Manufacture
KTA 3205.1	(2018-10)	Component Support Structures with Non-integral Connections; Part 1: Component Support Structures with Non-integral Connections for Components of the Reactor Coolant Pressure Boundary of Light Water Reactors
KTA 3205.2	(2018-10)	Component Support Structures with Non-integral Connections; Part 2: Component Support Structures with Non-Integral Connections for Pressure and Activity-Retaining Components in Systems Outside the Primary Circuit
KTA 3211.1	(2017-11)	Pressure and Activity Retaining Components of Systems Outside the Primary Circuit; Part 1: Materials
KTA 3211.2	(2013-11)	Pressure and Activity Retaining Components of Systems Outside the Primary Circuit; Part 2: Design and Analysis
KTA 3211.3	(2017-11)	Pressure and Activity Retaining Components of Systems Outside the Primary Circuit; Part 3: Manufacture
KTA 3301	(2015-11)	Residual Heat Removal Systems of Light Water Reactors
KTA 3401.2	(2016-11)	Steel Containment Vessels; Part 2: Analysis and Design
KTA 3401.3	(1986-11)	Steel Reactor Safety Containment; Part 3: Manufacture
KTA 3401.4	(2022-11)	Steel Containment Vessels; Part 4: In-service Inspections
KTA 3402	(2022-11)	Airlocks on the Reactor Containment of Nuclear Power Plants - Personnel Airlocks
KTA 3403	(2022-11)	Cable Penetrations through the Reactor Containment Vessel

KTA 3404	(2017-11)	Isolation of Operating System Pipes Penetrating the Containment Vessel in the Case of a Release of Radioactive Substances into the Containment Vessel of Nuclear Power Plants
KTA 3405	(2015-11)	Leakage Test of the Containment Vessel
KTA 3409	(2022-11)	Airlocks on the Reactor Containment of Nuclear Power Plants - Equipment airlocks
KTA 3601	(2022-11)	Ventilation Systems in Nuclear Power Plants
DIN EN ISO 1127	(2019-03)	Stainless steel tubes - Dimensions, tolerances and conventional masses per unit length (ISO 1127:1992); German version EN ISO 1127:1996
DIN EN 1779	(1999-10)	Non-destructive testing - Leak testing - Criteria for the method and technique selection; German version EN 1779:1999, Corrigendum 2005-02
DIN 1910-100	(2008-02)	Welding and allied processes - Vocabulary - Part 100: Metal welding processes with additions to DIN EN 14610:2005
DIN ISO 2768-1	(1991-06)	General tolerances; tolerances for linear and angular dimensions without individual tolerance indications; identical with ISO 2768-1:1989
DIN EN ISO 3059	(2013-03)	Non-destructive testing - Penetrant testing and magnetic particle testing - Viewing conditions (ISO 3059:2012); German version EN ISO 3059:2012
DIN EN ISO 3452-1	(2022-02)	Non-destructive testing - Penetrant testing - Part 1: General principles (ISO 3452-1:2021); German version EN ISO 3452-1:2021
DIN EN ISO 3452-2	(2022-02)	Non-destructive testing - Penetrant testing - Part 2: Testing of penetrant materials (ISO 3452-2:2021); German version EN ISO 3452-2:2021
DIN EN ISO 3452-3	(2014-03)	Non-destructive testing - Penetrant testing - Part 3: Reference test blocks (ISO 3452-3:2013); German version EN ISO 3452-3:2013
DIN EN ISO 3651-2	(1998-08)	Determination of resistance to intergranular corrosion of stainless steels - Part 2: Ferritic, austenitic and ferritic-austenitic (duplex) stainless steels - Corrosion test in media containing sulfuric acid (ISO 3651-2:1998); German version EN ISO 3651-2:1998
DIN EN ISO 4136	(2013-02)	Destructive tests on welds in metallic materials - Transverse tensile test (ISO 4136:2012); German version EN ISO 4136:2012
DIN EN ISO 5173	(2012-02)	Destructive tests on welds in metallic materials - Bend tests (ISO 5173:2009 + Amd 1:2011); German version EN ISO 5173:2010 + A1:2011
DIN EN ISO 6892-1	(2020-06)	Metallic materials - Tensile testing - Part 1: Method of test at room temperature (ISO 6892-1:2019); German version EN ISO 6892-1:2019
DIN EN ISO 9013	(2017-05)	Thermal cutting - Classification of thermal cuts - Geometrical product specification and quality tolerances (ISO 9013:2017); German version EN ISO 9013:2017
DIN EN ISO 9934-1	(2017-03)	Non-destructive testing - Magnetic particle testing - Part 1: General principles (ISO 9934-1:2016); German version EN ISO 9934-1:2016
DIN EN ISO 9934-2	(2015-12)	Non-destructive testing - Magnetic particle testing - Part 2: Detection media (ISO 9934-2:2015); German version EN ISO 9934-2:2015
DIN EN ISO 9934-3	(2015-12)	Non-destructive testing - Magnetic particle testing - Part 3: Equipment (ISO 9934-3:2015); German version EN ISO 9934-3:2015
DIN EN 10028-7	(2016-10)	Flat products made of steels for pressure purposes - Part 7: Stainless steels; German version EN 10028-7:2016
DIN EN 10160	(1999-09)	Ultrasonic testing of steel flat product of thickness equal to or greater than 6 mm (reflection method); German version EN 10160:1999
DIN EN 10164	(2018-12)	Steel products with improved deformation properties perpendicular to the surface of the product - Technical delivery conditions; German version EN 10164:2018
DIN EN 10204	(2005-01)	Metallic products - Types of inspection documents; German version EN 10204:2004
DIN EN 10216-1	(2014-03)	Seamless steel tubes for pressure purposes - Technical delivery conditions - Part 1: Non-alloy steel tubes with specified room temperature properties; German version EN 10216-1:2013
DIN EN 10216-2	(2020-04)	Seamless steel tubes for pressure purposes - Technical delivery conditions - Part 2: Non-alloy and alloy steel tubes with specified elevated temperature properties; German version EN 10216-2:2013+A1:2019
DIN EN 10217-1	(2019-08)	Welded steel tubes for pressure purposes - Technical delivery conditions - Part 1: Electric welded and submerged arc welded non-alloy steel tubes with specified room temperature properties; German version EN 10217-1:2019

DIN EN 10217-2	(2019-08)	Welded steel tubes for pressure purposes - Technical delivery conditions - Part 2: Electric welded non-alloy and alloy steel tubes with specified elevated temperature properties; German version EN 10217-2:2019
DIN EN 10217-5	(2019-08)	Welded steel tubes for pressure purposes - Technical delivery conditions - Part 5: Submerged arc welded non-alloy and alloy steel tubes with specified elevated temperature properties; German version EN 10217-5:2019
DIN EN 10228-1	(2016-10)	Non-destructive testing of steel forgings - Part 1: Magnetic particle inspection; German version EN 10228-1:2016
DIN EN 10228-2	(2016-10)	Non-destructive testing of steel forgings - Part 2: Penetrant testing; German version EN 10228-2:2016
DIN EN 10228-3	(2016-10)	Non-destructive testing of steel forgings - Part 3: Ultrasonic testing of ferritic or martensitic steel forgings; German version EN 10228-3:2016
DIN EN 10228-4	(2016-10)	Non-destructive testing of steel forgings - Part 4: Ultrasonic testing of austenitic and austenitic-ferritic stainless steel forgings; German version EN 10228-4:2016
DIN EN 10307	(2002-03)	Non-destructive testing - Ultrasonic testing of austenitic and austenitic-ferritic stainless steels flat products of thickness equal to or greater than 6 mm (reflection method); German version EN 10307:2001
DIN EN ISO 10675-1	(2022-03)	Non-destructive testing of welds - Acceptance levels for radiographic testing - Part 1: Steel, nickel, titanium and their alloys (ISO 10675-1:2021); German version EN ISO 10675-1:2021
DIN EN ISO 10893-2	(2020-10)	Non-destructive testing of steel tubes - Part 2: Automated eddy current testing of seamless and welded (except submerged arc-welded) steel tubes for the detection of imperfections (ISO 10893-2:2011 + Amd 1:2020); German version EN ISO 10893-2:2011 + A1:2020
DIN EN ISO 10893-4	(2011-07)	Non-destructive testing of steel tubes - Part 4: Liquid penetrant inspection of seamless and welded steel tubes for the detection of surface imperfections (ISO 10893-4:2011); German version EN ISO 10893-4:2011
DIN EN ISO 10893-5	(2011-07)	Non-destructive testing of steel tubes - Part 5: Magnetic particle inspection of seamless and welded ferromagnetic steel tubes for the detection of surface imperfections (ISO 10893-5:2011); German version EN ISO 10893-5:2011
DIN EN ISO 10893-6	(2019-06)	Non-destructive testing of steel tubes - Part 6: Radiographic testing of the weld seam of welded steel tubes for the detection of imperfections (ISO 10893-6:2019); German version EN ISO 10893-6:2019
DIN EN ISO 10893-8	(2020-10)	Non-destructive testing of steel tubes - Part 8: Automated ultrasonic testing of seamless and welded steel tubes for the detection of laminar imperfections (ISO 10893-8:2011 + Amd 1:2020); German version EN ISO 10893-8:2011 + A1:2020
DIN EN ISO 10893-9	(2020-10)	Non-destructive testing of steel tubes - Part 9: Automated ultrasonic testing for the detection of laminar imperfections in strip/plate used for the manufacture of welded steel tubes (ISO 10893-9:2011 + Amd 1:2020); German version EN ISO 10893-9:2011 + A1:2020
DIN EN ISO 10893-10	(2020-10)	Non-destructive testing of steel tubes - Part 10: Automated full peripheral ultrasonic testing of seamless and welded (except submerged arc-welded) steel tubes for the detection of longitudinal and/or transverse imperfections (ISO 10893-10:2011 + Amd 1:2020); German version EN ISO 10893-10:2011 + A1:2020
DIN EN ISO 10893-11	(2020-10)	Non-destructive testing of steel tubes - Part 11: Automated ultrasonic testing of the weld seam of welded steel tubes for the detection of longitudinal and/or transverse imperfections (ISO 10893-11:2011 + Amd 1:2020); German version EN ISO 10893-11:2011 + A1:2020
DIN EN 14917	(2022-02)	Metal bellows expansion joints for pressure applications; German version EN 14917:2021
DIN EN ISO 17636-1	(2013-05)	Non-destructive testing of welds - Radiographic testing - Part 1: X- and gamma-ray techniques with film (ISO 17636-1:2013); German version EN ISO 17636-1:2013
DIN EN ISO 19232-1	(2013-12)	Non-destructive testing - Image quality of radiographs - Part 1: Determination of the image quality value using wire-type image quality indicators (ISO 19232-1:2013); German version EN ISO 19232-1:2013
DIN EN ISO 19232-3	(2014-02)	Non-destructive testing - Image quality of radiographs - Part 3: Image quality classes (ISO 19232-3:2013); German version EN ISO 19232-3:2013
DIN EN ISO 20482	(2014-03)	Metallic materials - Sheet and strip - Erichsen cupping test (ISO 20482:2013); German version EN ISO 20482:2013
DIN 25410	(2012-07)	Nuclear facilities - Surface cleanliness of components

DIN 25435-2	(2021-05)	In-service inspections for primary coolant circuit components of light water reactors - Part 2: Magnetic particle and penetrant testing
DIN 50125	(2016-12)	Testing of metallic materials - Tensile test pieces
AD 2000-Merkblatt B 13	(2012-07)	Single-ply bellows expansion joints
AD 2000-Merkblatt HP 0	(2022-03)	Manufacture and testing of pressure vessels - General principles of design, manufacture and associated tests
AD 2000-Merkblatt HP 2/1	(2021-12)	Manufacture and testing of pressure vessels - Welding procedure test
AD 2000-Merkblatt HP 5/1	(2021-12)	Manufacture and testing of pressure vessels - Manufacture and testing of joints - Principles of welding practice
AD 2000-Merkblatt HP 5/2	(2019-05)	Manufacture and testing of joints - Production testing of welds, testing of the parent metal after post-weld heat treatment
AD 2000-Merkblatt HP 5/3	(2020-12)	Manufacture and testing of pressure vessels - Manufacture and testing of joints - Non-destructive testing of welded joints
AD 2000-Merkblatt HP 5/3 Addendum 1	(2020-12)	Manufacture and testing of pressure vessels - Non-destructive testing of welded joints - Minimum requirements for non-destructive testing methods
AD 2000-Merkblatt HP 7/1	(2021-06)	Manufacture and testing of pressure vessels - Heat treatment - General principles
AD 2000-Merkblatt HP 7/2	(2020-12)	Manufacture and testing of pressure vessels - Heat treatment - Ferritic steels
AD 2000-Merkblatt HP 7/3	(2015-04)	Manufacture and testing of pressure vessels - Heat treatment - Austenitic steels
AD 2000-Merkblatt HP 8/2	(2021-12)	Manufacture and testing of pressure vessels - Testing of steel sections
AD 2000-Merkblatt W 0	(2021-06)	Materials for pressure vessels - General principles for materials
AD 2000-Merkblatt W 2	(2022-03)	Materials for pressure vessels - Austenitic and austenitic-ferritic steels
VdTÜV Merkblatt 1153	(2012-10)	Guidelines for the suitability testing of welding filler materials; Welding Technology 1153