

# Safety Standards

of the  
Nuclear Safety Standards Commission (KTA)

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**KTA 3407 (06/91)**

Pipe penetrations through the Reactor Containment Vessel

Rohrdurchführungen durch den Reaktorsicherheitsbehälter

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

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# KTA SAFETY STANDARD

June 1991

Pipe penetrations through the Reactor Containment Vessel

KTA 3407

This KTA safety standard was prepared on behalf of Kerntechnischer Ausschuss (KTA) by the Nuclear Standards Committee, NKe.  
The NKe intends to publish a literal version of the (German) safety standard as DIN 25 432.

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PLEASE NOTE: Only the original German version of this safety standard represents the joint resolution of the 50-member Nuclear Safety Standards Commission (Kerntechnischer Ausschuss, KTA). The German version was made public in Bundesanzeiger No. 113a on June 23, 1992. Copies may be ordered through the Carl Heymanns Verlag KG, Luxemburger Str. 449, D-50939 Koeln (Telefax +49-221-94373-603).

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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:

<b>shall</b>	indicates a mandatory requirement,
<b>shall basically</b>	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 <b>shall normally</b> - are specified in the text of the safety standard,
<b>shall normally</b>	indicates a requirement to which exceptions are allowed. However, the exceptions used, shall be substantiated during the licensing procedure,
<b>should</b>	indicates a recommendation or an example of good practice,
<b>may</b>	indicates an acceptable or permissible method within the scope of this safety standard.

## Fundamentals

(1) The safety standards of the Nuclear Safety Standards Commission (KTA) have the task of specifying those safety related requirements which shall be met with regard to precautions to be taken in accordance with the state of science and technology against the damage arising from the construction and operation of the facility (Sec. 7 para. 2 subpara. 3 Atomic Energy Act), in order to attain the protection goals specified in the Atomic Energy Act and the Radiological Protection Ordinance (StrlSchV) and which are further detailed in "Safety Criteria for Nuclear Power Plants" of the Ministry of the Interior (BMI).

(2) Criterion 8.4 „Penetrations through the Reactor Containment Vessel“ of the „Safety Criteria for Nuclear Power Plants“ lays down requirements for pipe penetrations through the reactor containment vessel. 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, Parts 1 to 3
- b) KTA 3211, Parts 1 to 3
- c) KTA 3401, Parts 2 to 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.

*Note:*

*For pipe penetrations through concrete reactor containment vessels this safety standard may be applied accordingly upon agreement with the authorized inspector.*

(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 sleeve 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 and Air Filtration 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.

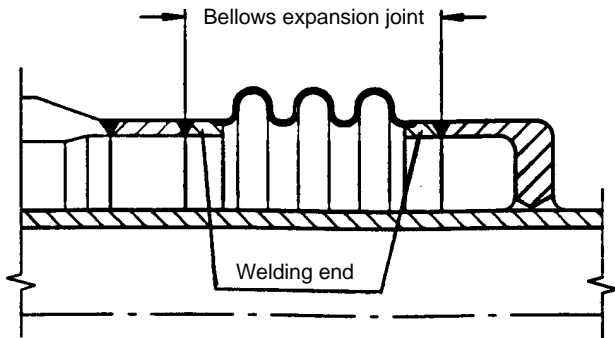
- a) Design loading level R1 covers the requirements for components of pipes used for enclosing the reactor coolant and the reactor containment vessel boundary.
- b) Design loading level R2 covers the requirements for components of pipes of specific safety-related impor-

tance with regard to their failure (see general basic safety specification) 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**).



**Figure 2-1:** Welding end

(3) Working pressure

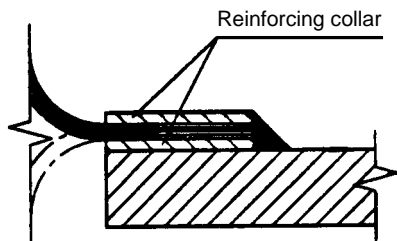
The working pressure of a fluid is the inner or outer gauge pressure intended for the course of one or several basic operations in a plant component.

(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

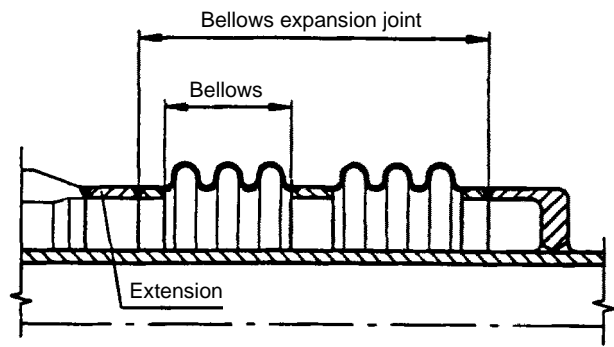
A bellows is a convoluted pipe the convolutions of which are capable of performing axial, angular and lateral movements due to their flexibility. Reinforcing collars (see **Figure 2-2**) and parts for guiding the convolutions are not part of the bellows.



**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**).

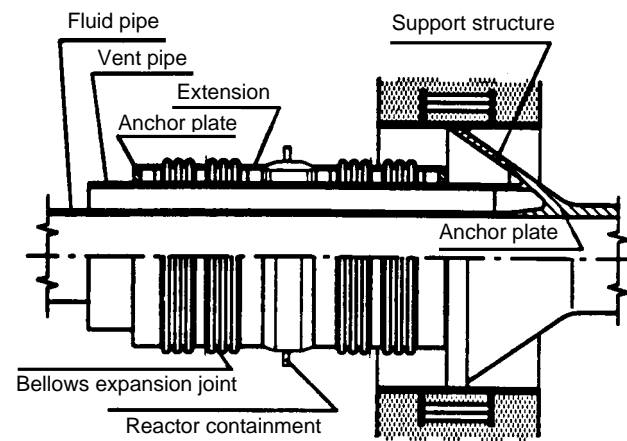


**Figure 2-3:** Bellows expansion joint

(7) Components of pipe penetrations

These are:

- a) fluid pipes inside or outside the penetrated section
- b) anchor plates, forged or welded
- c) vent 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 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 1.
- b) Part group 2 comprises components welded to part group 1 components including their attachment welds.

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

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

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

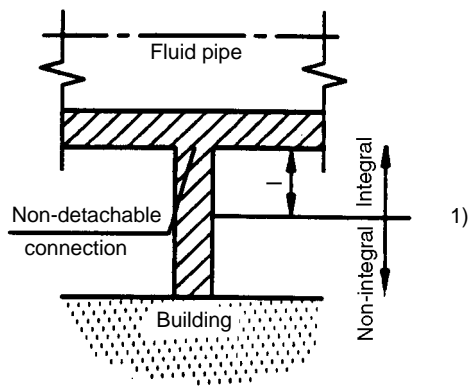
(12) Pipe penetrations

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

(13) Support structures

a) Integral support structures

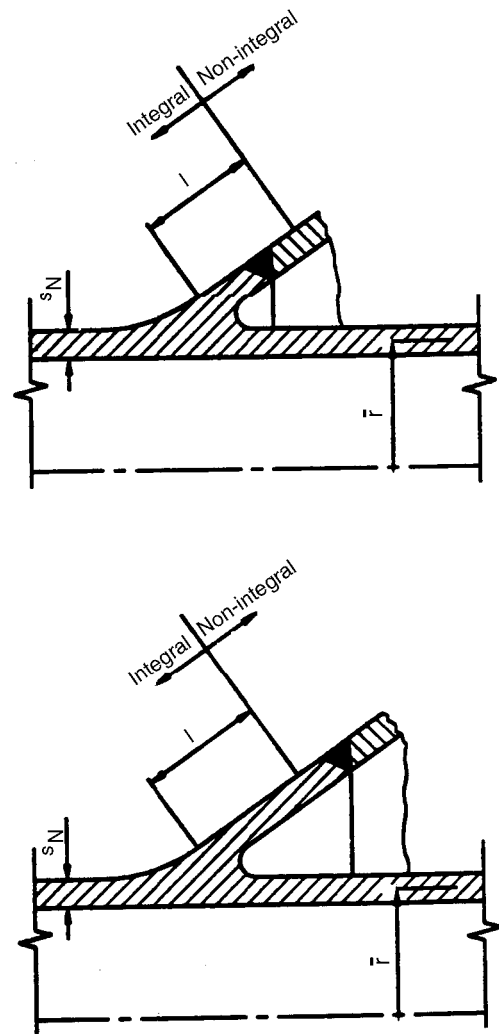
Integral support structures are components which are rigidly attached to the pipe or pipe penetration (e.g. welded, forged, machined from the solid) and have support functions (see Figure 2-5).



1) Limit of area of influence of fluid pipe

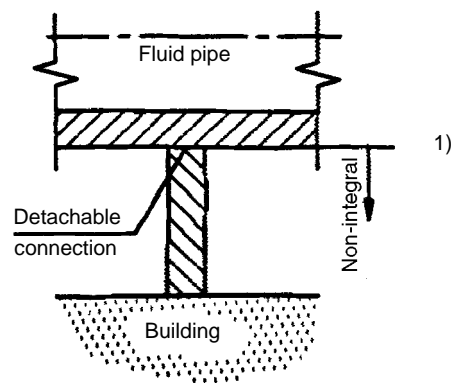
**Figure 2-5:** Schematic representation of integral support structures

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).



**Figure 2-6:** Examples of support structures

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).



1) Limit of area of influence of fluid pipe

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

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**).

#### (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 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 2, the materials to Annex B are permitted for design loading levels 1 to 3.

(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. vent 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.

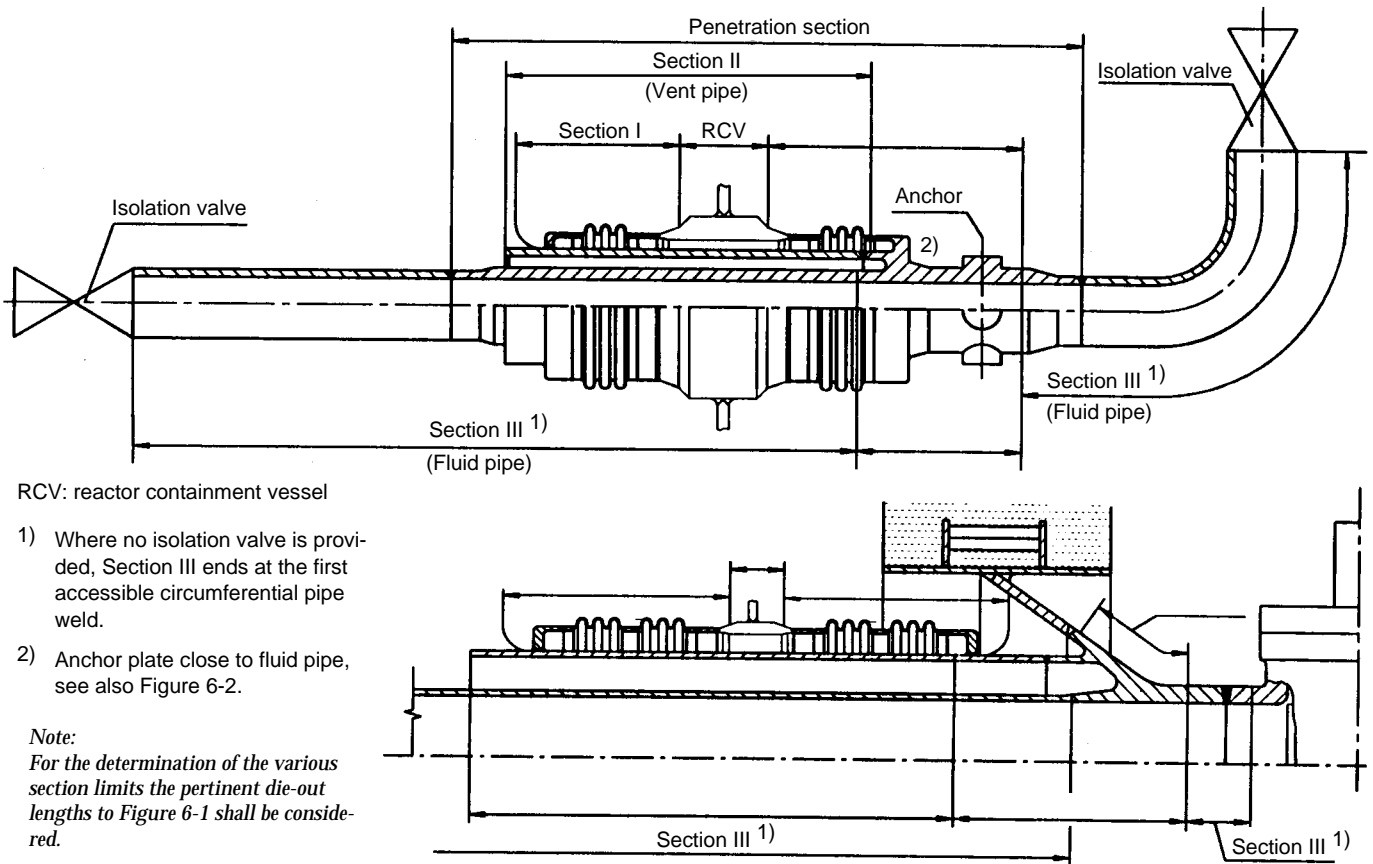


Figure 4-1: Representation of Sections I, II and III for assignment of safety requirements

#### 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 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.

- 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 A3 lays down the requirements for the design of bellows expansion joints.

Penetrating pipe covered by	Pipe penetration components						
	Fluid pipe outside the penetrated section <sup>1)</sup>	Non-integral support structures		Fluid pipe in penetrated section <sup>1)</sup> and forged anchor plate, if any	Forged anchor plate, fluid and vent pipe		Bellows expansion joint
		Beam load bearing structures	Plane load bearing structures		Non-chambered	Chambered	
KTA 3201	KTA 3201	KTA 3205.1	Annex B	R 1	R 2	R 3 <sup>2)</sup>	R 3 <sup>2)</sup>
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		R 2 with additional requirements to KTA 3111.3, Section 14	R 2	R 3 <sup>2)</sup>	R 3 <sup>2)</sup>
KTA 3211	KTA 3211	KTA 3205.2		R 2	R 2	R 3 <sup>2)</sup>	R 3 <sup>2)</sup>
Technical rules beyond the scope of KTA safety standards	Annex B	KTA 3205.2		R 2 <sup>3)</sup>	R 2 <sup>3)</sup>	R 3 <sup>2)</sup>	R 3 <sup>2)</sup>

1) For ≤ DN 50 the requirements for small dimensions shall be agreed upon 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 the reactor containment vessel sleeve (see **Figure 5-1.2**). Pipes with DN > 25 shall basically be assigned to have the same redundancy and, if used for conveying reactor coolant, shall be isolatable. Several pipes with 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 vent pipe (see **Figure 5-3**)
- d) design type IV, with bellows expansion joint on both sides of the containment vessel wall, with chamber and vent pipe (see **Figure 5-4.1** and **5-4.2**)
- e) special designs (rigid attachment, without chamber, with vent 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, sub-clauses 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<sup>2</sup> during operation.

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

### 5.5 Possibility of decontamination

The external surfaces of pipe penetrations shall make a decontamination possible, except for bellows.

### 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 (vent 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, code class 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.

(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

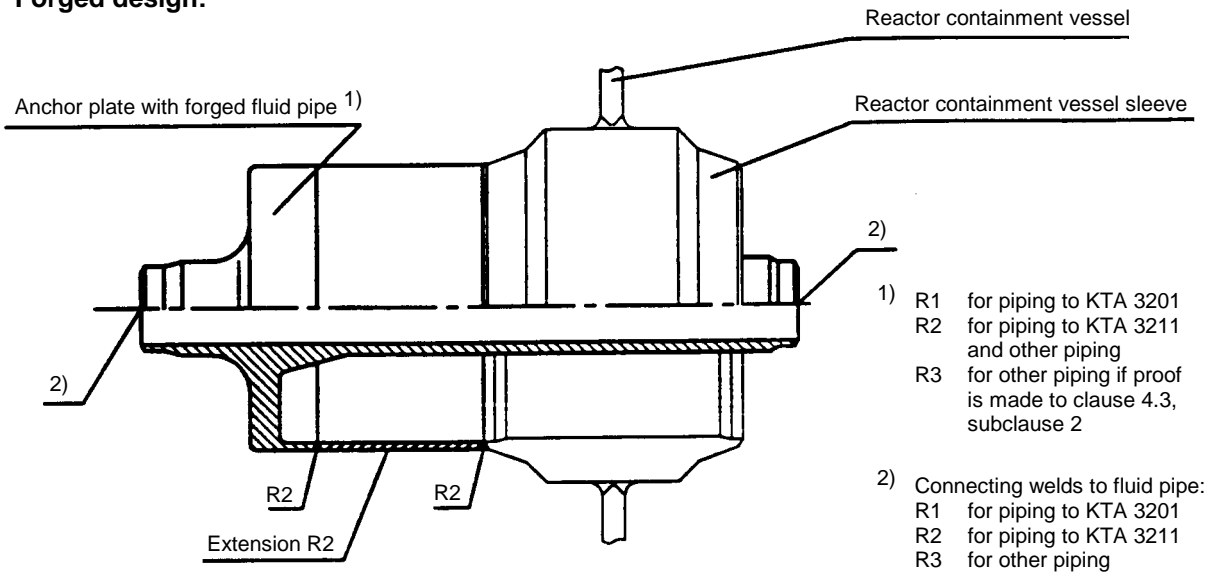
- pressure build-up due to heating of the contained fluid
  - b) Loadings imposed by the containment vessel:
    - possible overpressure (operating pressure)
    - local pressure build-up
  - c) Loadings imposed by relative movements between fluid pipe and containment vessel in due consideration of restraints 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**

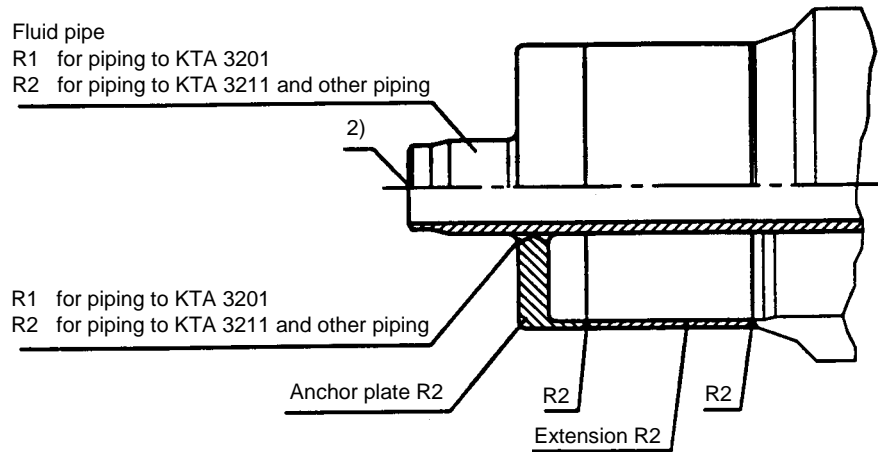
The calculation of non-integral support structures shall be made for

- 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, code class A2.

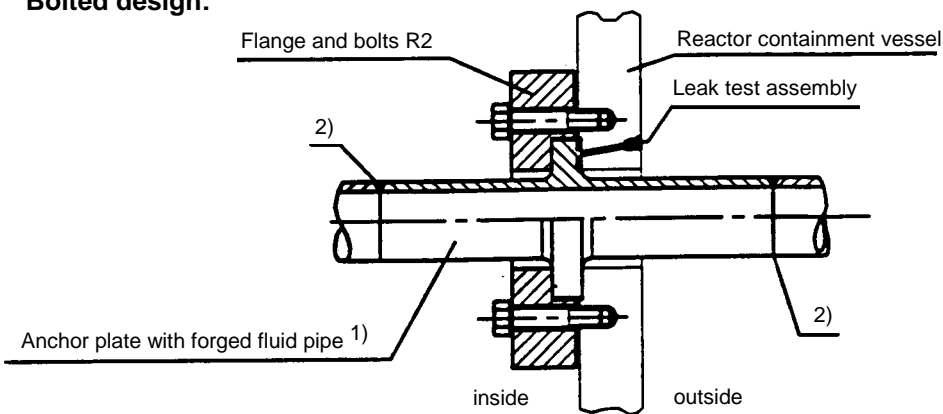
**Forged design:**



**Welded design:**

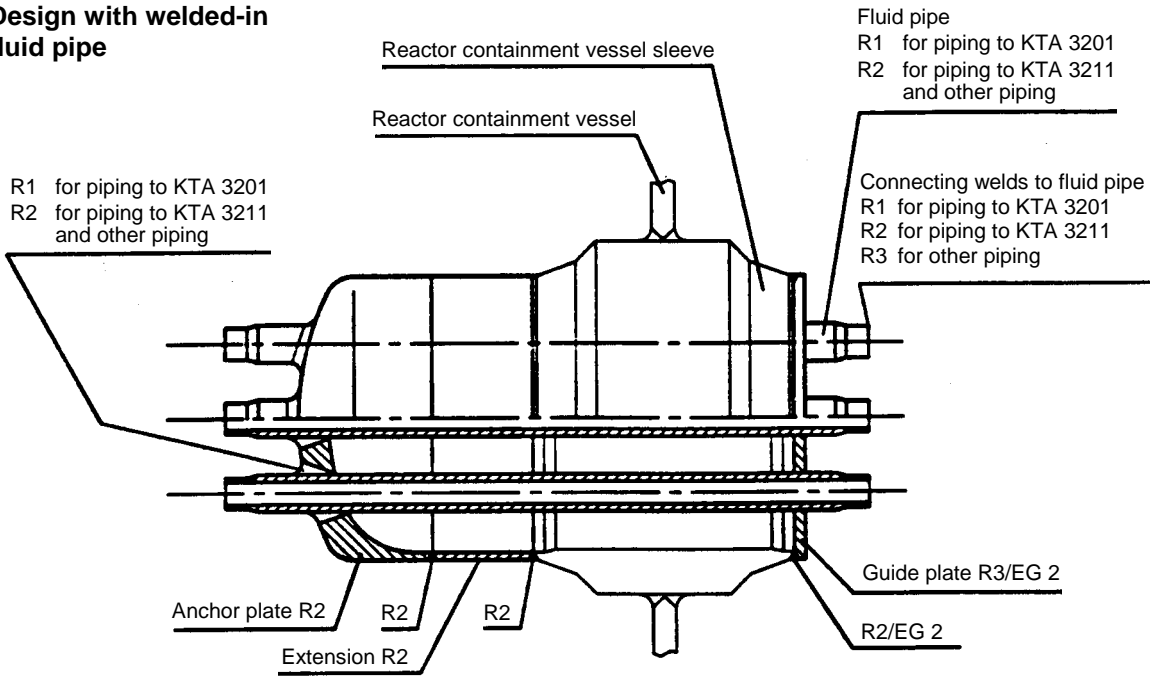


**Bolted design:**

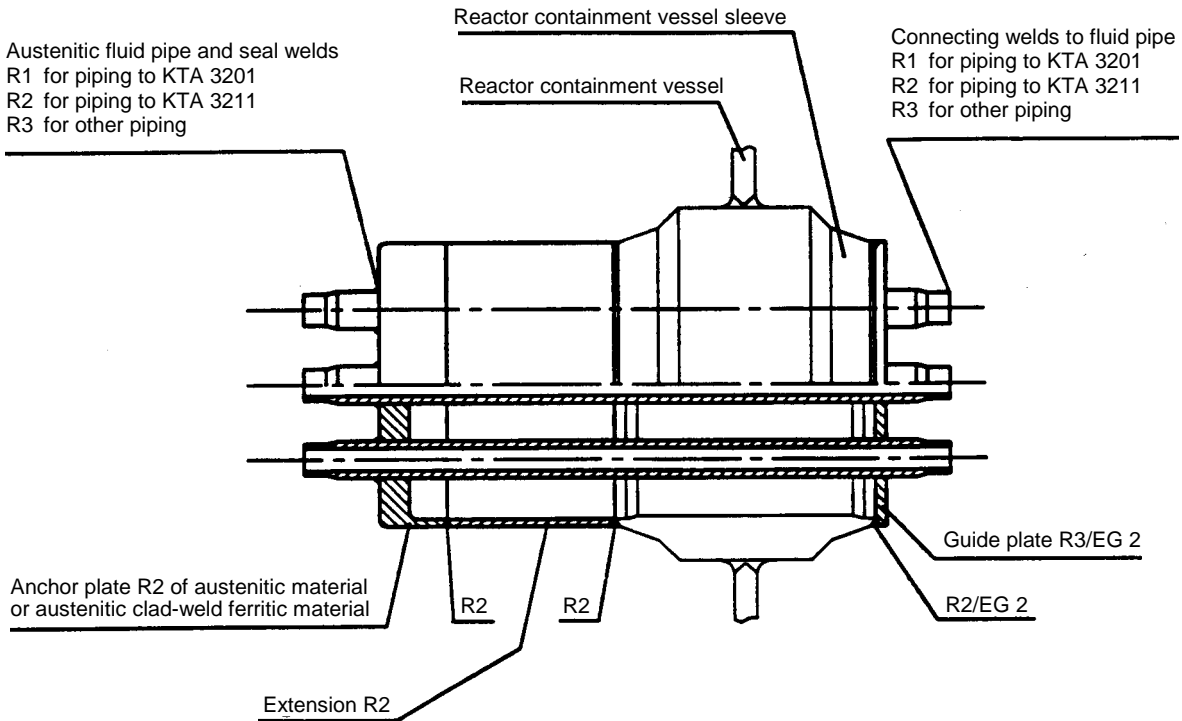


**Figure 5-1.1:** Examples of pipe penetration of design type I with fluid pipe and identification of design loading levels R1, R2 and R3

**Design with welded-in fluid pipe**



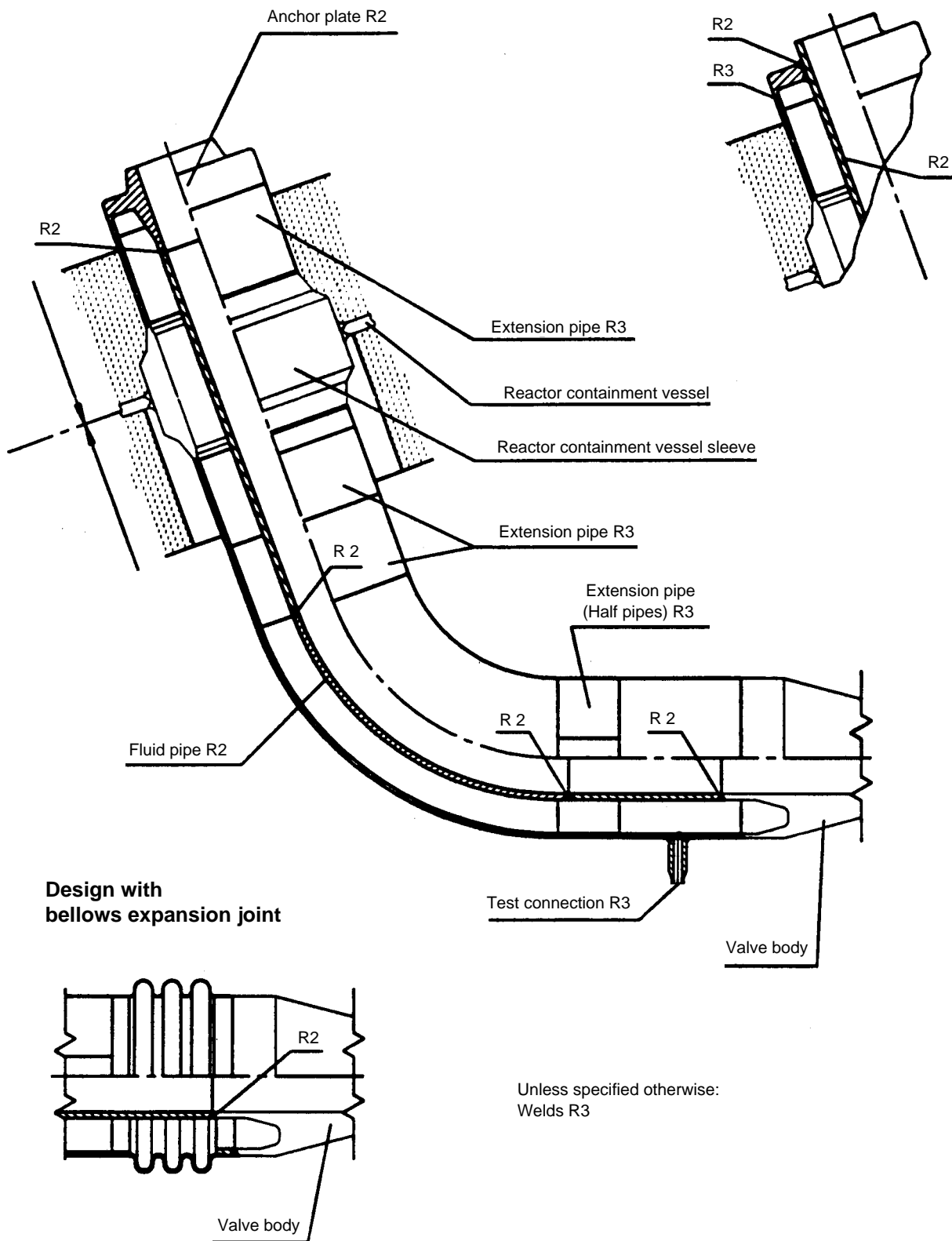
**Design with rolled or hydraulically expanded pipe**



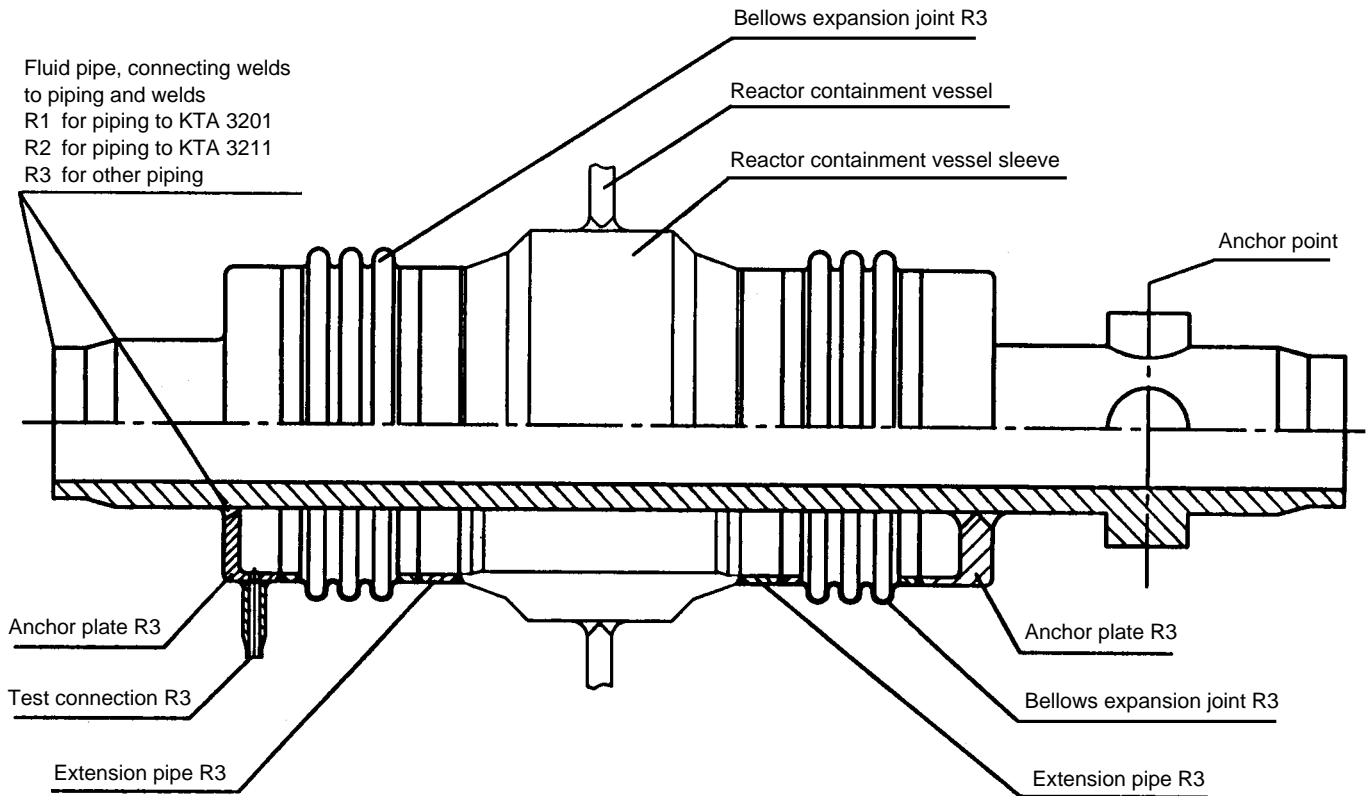
**Figure 5-1.2:** Example of pipe penetration of design type I with several fluid pipes and identification of design loading levels R1, R2 and R3

**Forged anchor plate**

**Welded anchor plate**

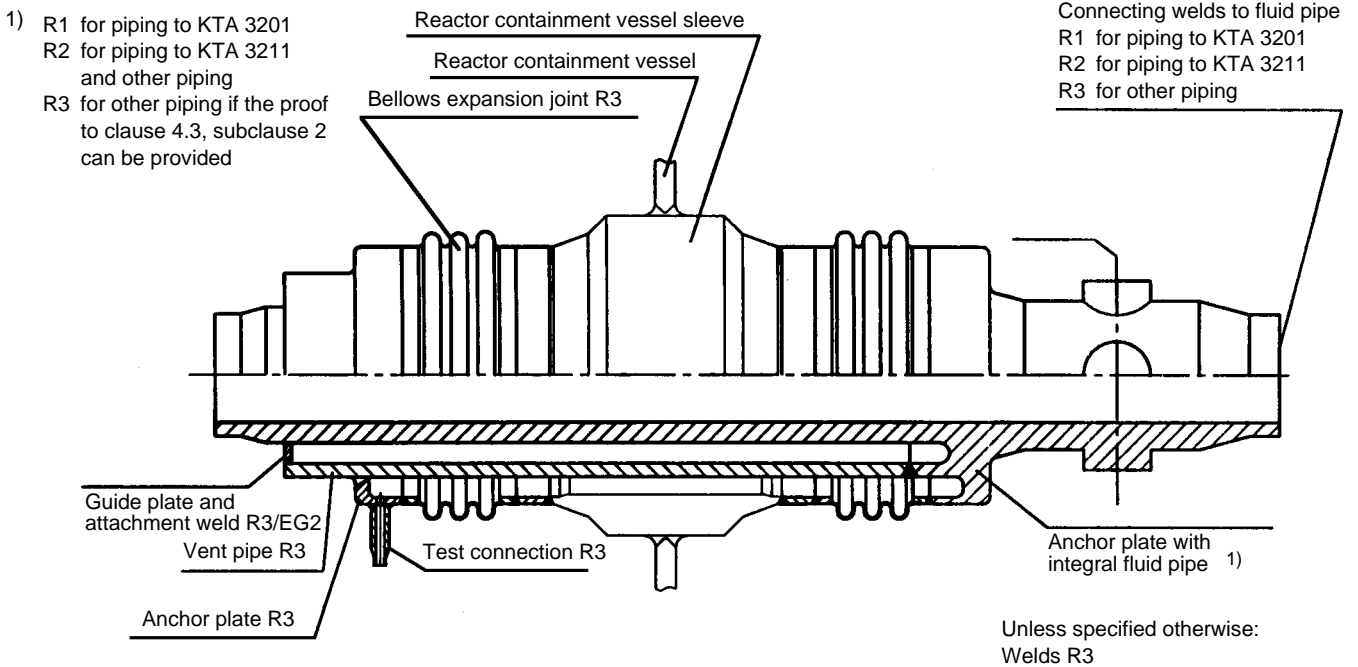


**Figure 5-2:** Example of pipe penetration of design type II and identification of design loading levels R2 and R3

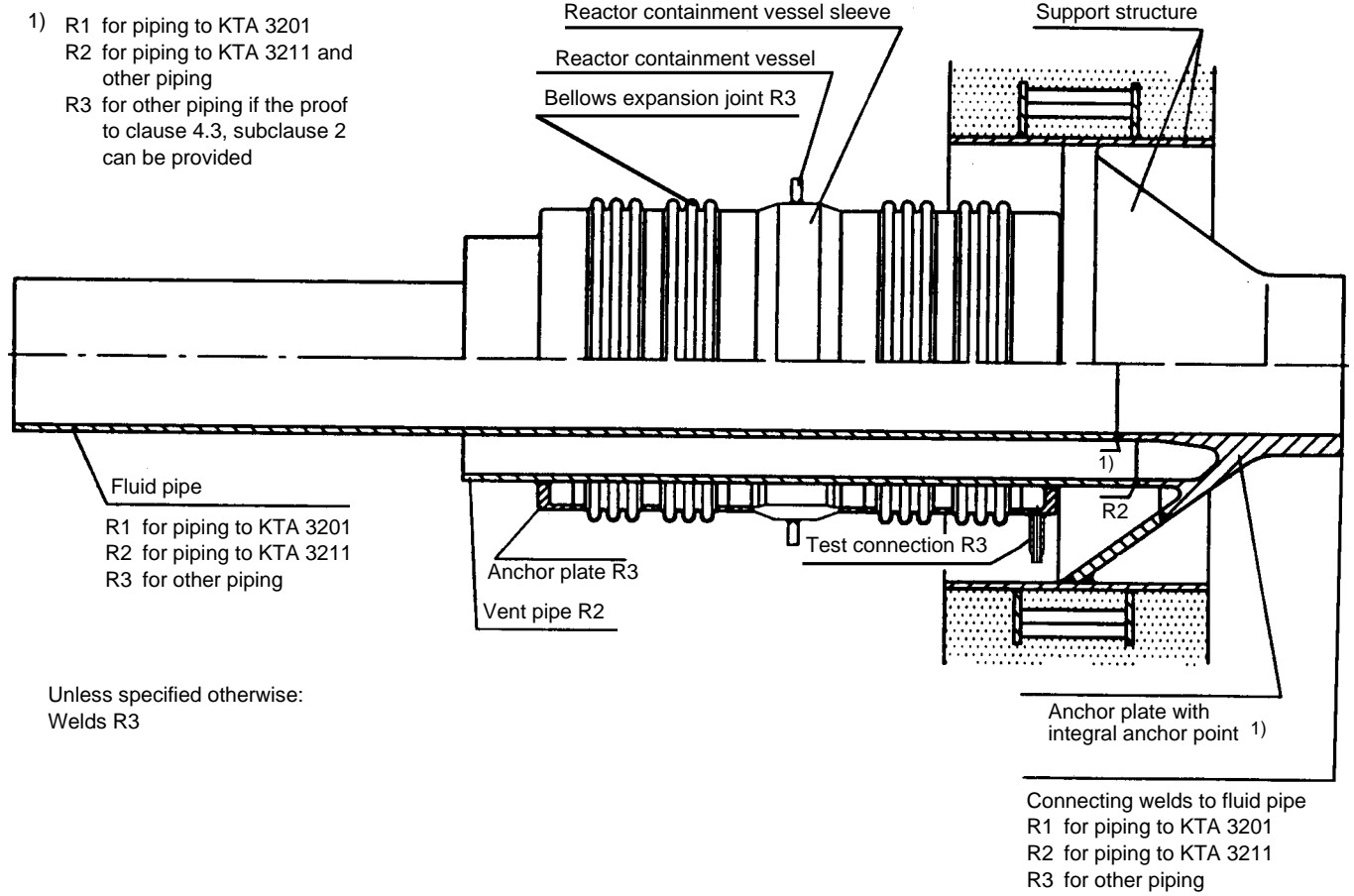


Unless specified otherwise:  
Welds R3

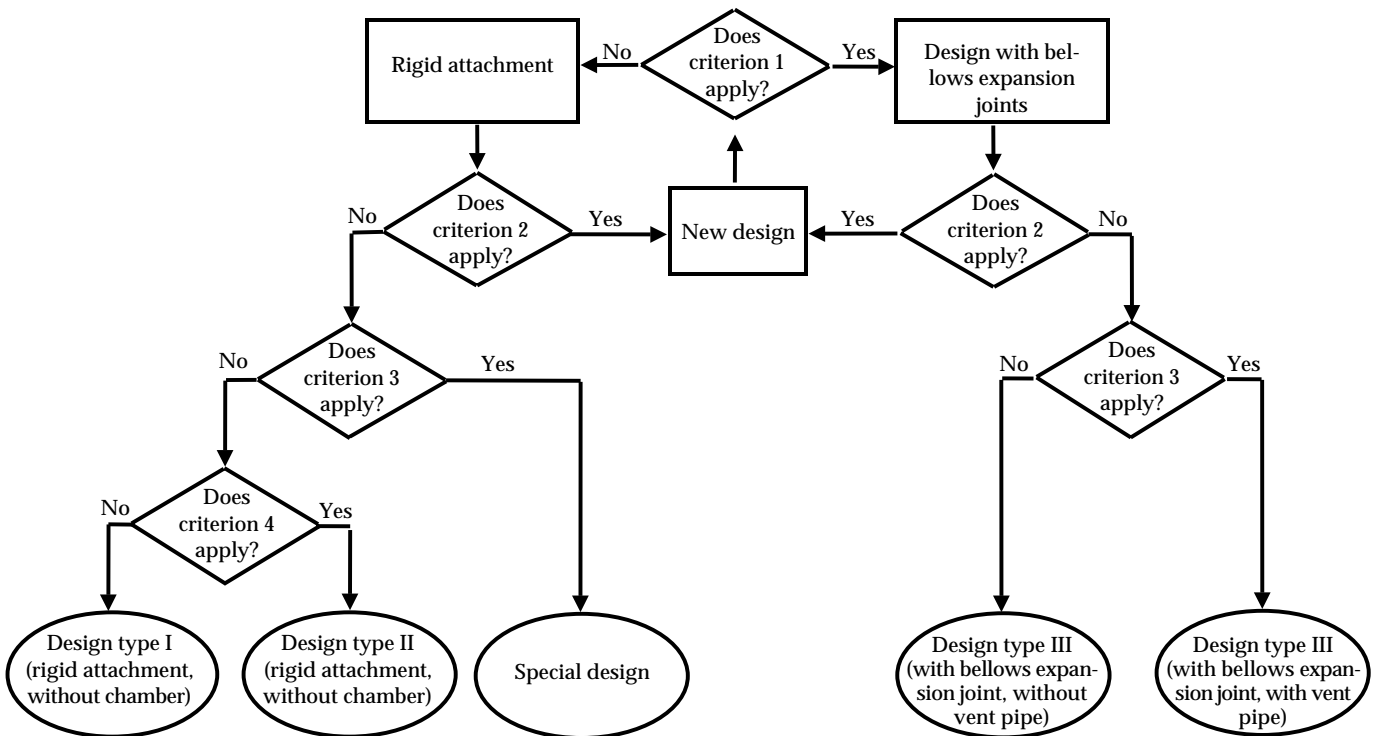
**Figure 5-3:** Example of pipe penetration of design type III and identification of design loading levels R1, R2 and R3



**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

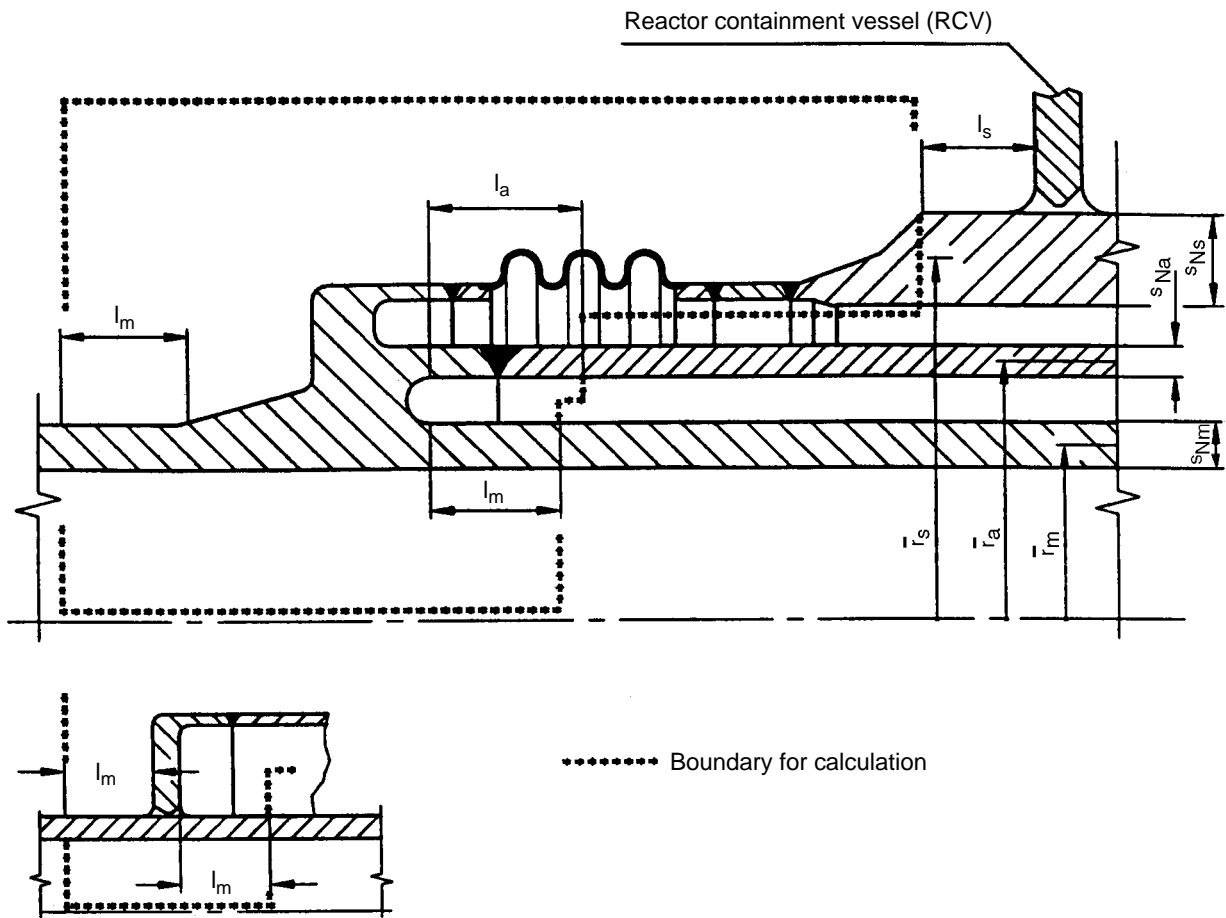


**Figure 5-4.2:** Example of pipe penetration of design type IV with integral anchor point and identification of design loading levels R1, R2 and R3



**Figure 5-5:** Determination of pipe penetration design types





Determination of die-out lengths

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

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

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

Notation:

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

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

Design requirement	Sections to Figure 4-1		
	Section III (Fluid pipe)	Section I (Section to Figure 7-1)	Section III (Fluid pipe)
Stepped wall thickness transition			
Conical wall thickness transition			
Conical transition			
Assigned loading level	<p>D for design loading levels R1 and R2 for all materials</p> <p>D for design loading level R3 for austenitic materials and 15 MnNi 6 3</p> <p>C for design loading level R3 for all other materials</p>	<p>B for design loading levels R1, R2 and R3 in connection with Table 6-1</p>	<p>D for design loading levels R1 and R2 for all materials</p> <p>D for design loading level R3 for austenitic materials and 15 MnNi 6 3</p> <p>C for design loading level R3 for all other materials</p>
<p>Design loading levels C or D shall only be substantiated by way of calculation for the unreinforced area.</p>			
<p>1) Required if fluid pipe is assigned to design loading level R3.</p>			

**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 1 (without bellows expansion joints)	KTA 3201.3	KTA 3211.3	Annex B
Part group 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 <b>Table 4-1</b> )			

**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 prestressing shall be considered, and the required protection against damage shall be provided at this construction stage.

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

#### 9.2.2 Pressure and leak tests

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

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

- to a gas pressure test with 1.1 times the allowable working pressure of the bellows expansion joint
- a leak test

(3) A leak rate of up to  $10^{-3}$  hPa x l x s<sup>-1</sup> is permitted. The following test procedures are e.g. permitted: tests with foaming agents, vacuum or pressure change test per unit of time, nitrogen or helium leak test.

(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:

- KTA 3201.3 for pipe penetration components of design loading level R1
- KTA 3211.3 for pipe penetration components of design loading level R2
- 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

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## 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 be used. Other materials are subject to agreement by the authorized inspector.

#### A 2.1.2 Requirements for materials

The values of DIN 17441 shall apply.

#### A 2.1.3 Materials testing and certificates

For the testing and certification of materials AD-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-Merkblatt W0, Section 2 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. Exceptions to this rule are subject to agreement by the authorized inspector.

(3) For cold-rolled or laminated bellows the fatigue behaviour shall be substantiated for each individual case by means of calculation (see clause A 5.3). This may be omitted if the cold-rolled bellows is subjected to a heat treatment (solution annealing) after rolling.

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

(5) 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.

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

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

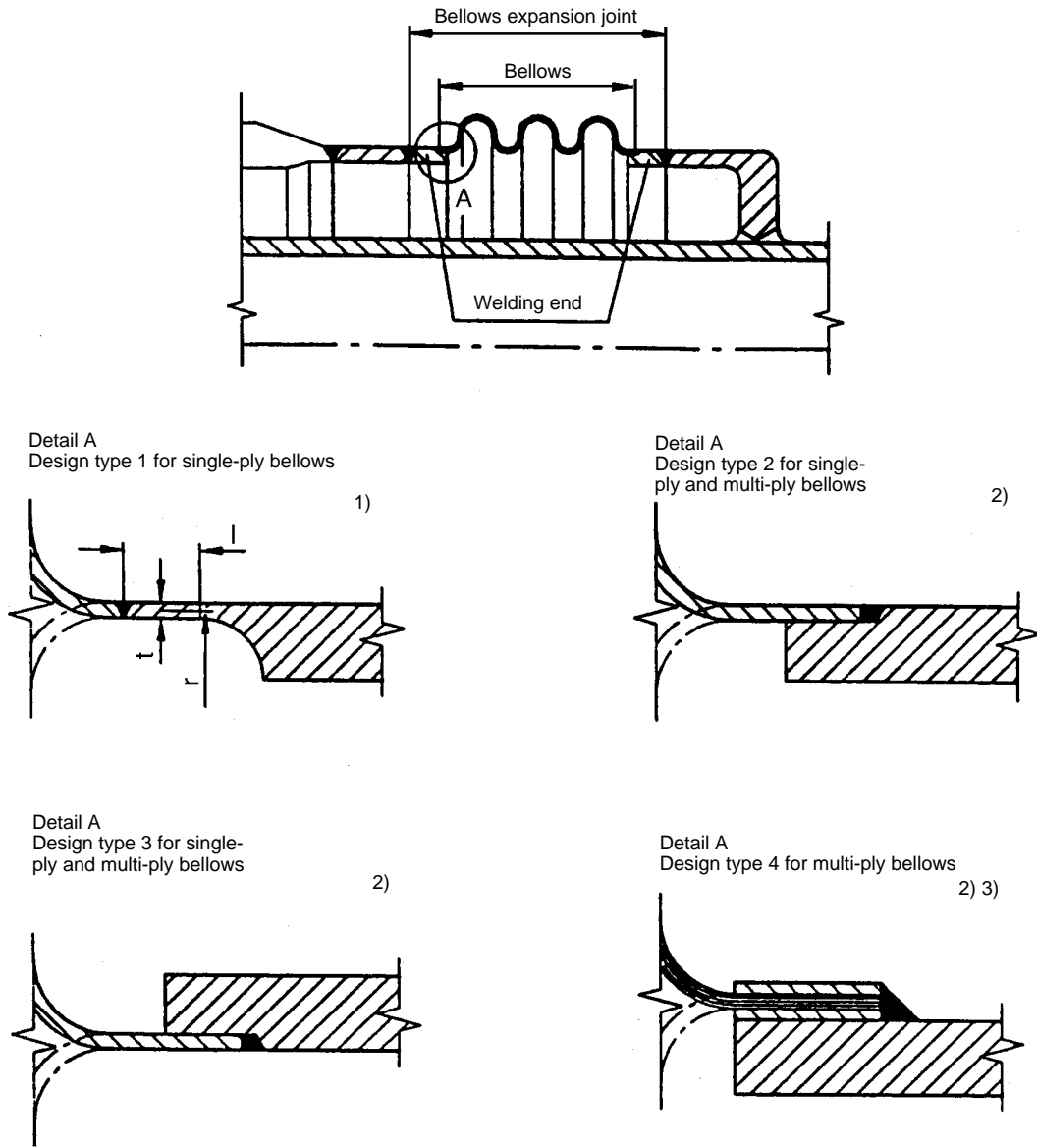
**A 4.2.2 Tolerances**

(1) The following tolerances shall be adhered to:

a) to DIN 2462, Part 1 for seamless pipes made of austenitic materials

- b) to DIN 2463, Part 1 for longitudinally welded pipes made of ferritic materials
- c) to DIN 17175 or DIN 1630 for seamless pipes made of ferritic materials
- d) to DIN 1626 for longitudinally welded pipes made of ferritic materials
- e) to DIN 7168, Parts 1 and 2, „mean“ general tolerance 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:  $l \leq 0.5 \sqrt{r \cdot t}$
- 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 ranging from 3 mm up to 0.7 times the smallest wall thickness (see Figure A 4-2)

#### A 4.3.4 Misalignment

The allowable misalignment (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.

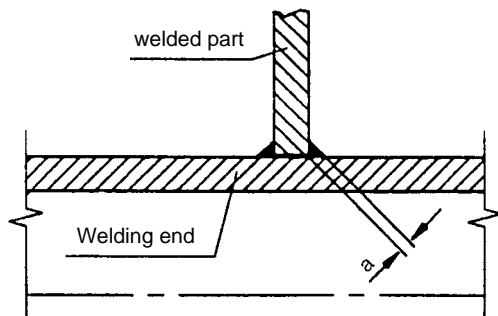


Figure A 4-2: Welded attachment

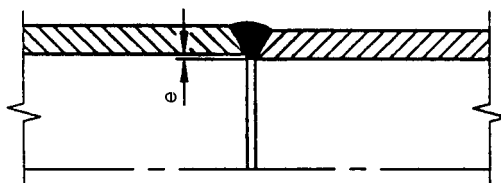


Figure A 4-3: Misalignment

## A 5 Calculation

### A 5.1 General

(1) Bellows are loaded by internal and external pressure as well as forced movements (axial and lateral displacement, angular rotation) and are subject to cyclic loading during operation. Major torsional loading is basically not permitted. If required, remedial measures shall be taken (e.g. by pipe anchors) or the loading shall be substantiated by way of calculation in each individual case.

(2) 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

$\alpha$  maximum rotation angle of the first convolution during lateral movement, in degree. This angle shall be inserted in equation 5 of AD-Merkblatt B 13.

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

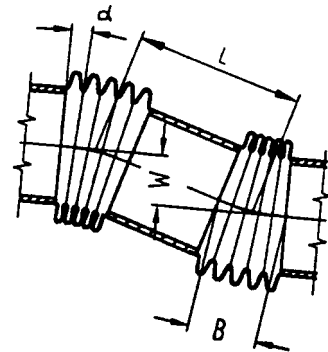


Figure A 5-1: Bent beam model

### A 5.2 Proof of strength of single-ply bellows

The strength of single-ply bellows to withstand internal or external pressure shall be calculated using AD-Merkblatt B 13. Differing herefrom, the following stipulations apply.

a) Safety factors for

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

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

b) For each bellows expansion joint it shall be proved that it is adequately dimensioned to withstand buckling or instability (e.g. by means of tests to be performed or having already been performed on comparable bellows expansion joints).

c) For the calculation against fluctuating loadings the load cycle safety factor against leakage shall be  $S_L = 5$ .

### A 5.3 Proof of strength of laminated bellows

(1) For laminated bellows clause A 5.2 may be used analogously in which case the differing section modulus and mutual constraints shall be taken into account. If required,

shape factors shall be determined by means of suitable numerical procedures.

(2) To consider constraints and friction between the individual layers, a load cycle safety factor of  $S_L = 20$  shall be selected.

(3) Where a calculation is made for an individual case, a load cycle safety factor of  $S_L = 5$  referred to the number of load cycles will suffice which is to be obtained by 95 % of the tests. Here, at least 20 individual tests on representative bellows expansion joints shall be performed to cover especially

- a) bursting
- b) non-permitted deformation
- c) instability
- d) fatigue.

(4) For the remaining 5 %, the load cycle safety shall not be less than  $S_L = 2$ .

#### 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 1910, Part 1 without welding filler metals the welding procedure to be used shall be indicated in the drawing instead of the welding procedure sheet).
- f) calculation

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

### A 7 Manufacture

#### A 7.1 Requirement to be met by the manufacturer

The bellows expansion joint manufacturer (including the bellows manufacturer) shall be qualified to AD-Merkblatt HP0. The fabrication shall be performed to design-approved documents.

#### 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 throat 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) liquid penetrant testing to AD-Merkblatt HP 5/3 at a wall thickness of 1 mm and more.
  - ab) 2 tensile tests on flat tensile specimens taken from the welded joint to DIN 15120 at room temperature, however with a test length  $L_C = \text{weld joint width} + 2 \times 40 \text{ mm}$ . By these tests, the tensile strength  $R_m$  and location of crack shall be determined.
  - ac) 2 bend tests each to DIN 50121 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  $180^\circ$  is deemed to have been obtained if the bend test specimen has been made to DIN 50121 and has been pressed through the supports without cracking.

Where a bending angle smaller than  $180^\circ$ , but up to and including  $90^\circ$  is obtained, the bending strain ( $L_0 = \text{weld joint width} + \text{wall thickness}$ , symmetrical to the weld) shall correspond to the elongation at fracture  $A_5$  of the base material for a short proportional bar.

Where a bending angle smaller than  $90^\circ$  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. X 8 Ni 9) deviating values may be agreed 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 for a short proportional bar.
- ae) 3 cupping tests to DIN 50101, Part 1 or 2 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 be obtained in the area of the base metal.
- af) Per specimen 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 50 914.
- 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 liquid penetrant inspection to AD-Merkblatt HP 5/3
- bb) a radiographic examination only of the circumferential weld between bellows and welding end
- 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 50914.

#### 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 (cupping test, drift expanded specimen) that has been qualified within the qualification procedure and has been agreed upon 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 Annex 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 VdTUV-Werkstoffprüfblätter and AD-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 liquid penetrant examination 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) liquid penetrant examination 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 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 joint 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 herefrom, 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 examination**

(1) Each bellows shall be subjected to a radiographic examination to DIN 54111, Part 1, test class B.

- a) Extent of examination 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) Requirements:  
AD-Merkblatt HP 5/3, image quality level I to DIN 54109, Part 3.

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

**A 8.3 Surface crack detection**

Each bellows shall be subjected to a surface crack detection to AD-Merkblatt HP 5/3 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 examination 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) Requirements:**

For longitudinal and circumferential welds no indications are permitted. Other welds to clause A 4.3.3 shall be assessed in accordance with AD-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 50145 (certificate to DIN 50049 - 3.1 C)
- b) 1 test for resistance to intergranular corrosion to DIN 50914 (certificate to DIN 50049 - 3.1 B)

(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.

**A 8.7 Leak testing**

Upon pressure testing, the bellows expansion joint shall be completely dried and checked again for cleanliness. Following this check, the gas leak tightness shall be proved at the manufacturer's works in the presence of the authorized inspector. A leak rate of up to  $10^{-3}$  hPa x l x s<sup>-1</sup> is permitted. Foaming agent, nitrogen or helium leak tests are permitted as test procedure.

## Annex B

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

#### Contents

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  - B 4.9 Tolerances
  - B 4.10 Manufacturing supervision and final inspection
  - B 4.11 Non-destructive examination (NDE) on welds

**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 of part group 2 and for the pressure-retaining wall of components of part group 2 of design loading level R3.

(2) The classification of components can 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) The allowable materials can be taken from **Table B 2-1**.

(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**

AD-Merkblatt W0 covers the requirements to be met by the manufacturer.

Type of material	
(1) Ferritic materials	a) materials of material groups WI and WII to KTA 3211.1 b) materials to material group 1 to AD-Merkblatt HP0 In the case of carbon or low-alloy ferritic steels only the killed steel qualities are permitted. c) the materials 10 CrMo 9 10, 13 CrMo 4 4, only in the case of special operational loadings (e.g. wear, corrosion, erosion) upon agreement by the authorized inspector
(2) Austenitic materials	(a) stabilized austenitic steels X 6 CrNiTi 18 10 (1.4541) X 6 CrNiNb 18 10 (1.4550) X 6 CrNiMoTi 17 12 2 (1.4571) X 6 CrNiMoNb 17 12 2 (1.4580) (b) non-stabilized steels X 3 CrNiMoN 17 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-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 within narrow limits, the following limit values shall be adhered to by plates, pipes and forgings made from allowable materials to **Table B 2-1**, line (1):

$$P \leq 0.035 \%, S \leq 0.030 \%$$

*Note:*

*The heat may be selected freely.*

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

- a) minor dimensions ( $\leq$  DN 80 or  $s \leq$  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 upon agreement with the authorized inspector
- e) unwelded components
- f) qualified 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 SEL 096, quality class Z 25 shall be adhered to.

**B 2.3 Non-destructive examination of products**

The non-destructive examinations to be performed shall be read from **Table B 2-2**.

**B 2.4 Proof of quality**

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

(2) The results of the non-destructive examination shall be certified by the manufacturer with acceptance test certificate B to DIN 50049.

Type of product	Type of examination		
	Ultrasonic examination	Surface crack detection to AD-Merkblatt HP 5/3	Radiographic examination
Plates s > 10 mm	Anchor plates: edge zone examination to SEL 072, class 1	none	none
Pressed and dished parts	none	Half pipes, flange edge and knuckle of heads <sup>1) 2)</sup> at a 100 %	none
Pipes (seamless)	Ferrite: to SEP 1915, grade III Austenite: to AD W2	none	none
Pipes (longitudinally welded)	Pipes: to DIN 17177 Grade I: to SEP 1917 (B) Grade III: to SEP 1915 Fusion welded pipes: to SEP 1916	CrMo steels: 100 % of the welds other steels: spot checks	Austenite: s > 6 mm: 100 % to AD HP 5/3 s ≤ 6 mm: 100 % eddy current testing
Reducers, pipe bends (seamless)	none	10 % <sup>2)</sup>	none
Reducers, pipe bends (longitudinally welded)	Ferrite: s ≤ 20 mm: 100 % ultrasonic examination (B) s ≥ 20 mm: 100 % ultrasonic examination (C) to AD HP 5/3 Where ≤ 85 % of the nominal operating stress are utilized: 10 %	CrMo steels: 100 % of the welds Other steels: spot checks	Ferrite: s ≤ 20 mm alternatively to a 100 % ultrasonic examination D (B) to AD HP 5/3 Austenite: 100 % radiographic examination (B) to AD HP 5/3 Where ≤ 85 % of the nominal operating stress are utilized: 10 %
Forgings	Ferrite: 100 % volumetric testing to AD W 13 or AD W12	100 % in finished <sup>2)</sup> condition, where the part weight > 300 kg	none
<sup>1)</sup> Omitted for cold-formed components without heat treatment after cold-forming <sup>2)</sup> Discontinuities are not permitted.			

**Table B 2-2:** Non-destructive testing

### 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

The requirements of AD-Merkblatt HP0 apply with respect to the manufacturer's qualification.

#### 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).

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 (radiography)	E
3.12	Test report (ultrasonic examination, radiography)	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

(3) Thermally cut fusion faces shall satisfy quality level I to DIN 2310, Part 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  $R_{p0.2 RT}$  greater than 370 N/mm<sup>2</sup> 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).

**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 not be exceeded. Otherwise, the excessive hardness shall be subject to agreement by the authorized inspector.

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

(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) (W) St E 355 and 15 MnNi 6 3 (if no stress relieving is performed after welding)

b) materials with  $R_{0.2 RT}$  greater than 370 N/mm<sup>2</sup>

(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 (examination 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 crack detection.

### **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 assessment**

In addition to the requirements of AD-Merkblatt HP 5/1 the following applies:

- a) for the misalignment of pipe circumferential welds  $0.15 \cdot s$ , with a maximum of 2 mm  
b) for fillet welds DIN 8563, Part 3, quality level BK.

#### **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-Merkblatt HP 2/1 shall apply. Alternatively, advance production control tests are permitted within the procedure qualification.

- (2) Where AD-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-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 50914.

## 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-Merkblatt HP 2/1 the following applies:

## a) Deposition welding

Surface crack detection, proof of strength and ductility (bending test), 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) agreement shall be reached 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-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-Merkblatt HP 5/2.

(2) For welds for which no stipulations are laid down by AD-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, filler 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-Merkblatt HP 5/2.

(2) The stipulations of clause B 4.4.3 apply additionally to AD-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-Merkblätter HP 7/2 and HP 7/3 are not exceeded.

(2) Where the degree of cold forming is exceeded during cold forming, a heat treatment and testing of the material to include non-destructive examinations 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. VdTUV-Werkstoffblätter, AD-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:

- heat treating and forming facilities
- degree of forming (unless a heat treatment is performed)
- heat input.

**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 examination 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**

- The out-of-roundness shall not exceed 5 % (on welds it shall be smaller than or equal to 2 %).
- The ovality shall be determined during the inspection.
- The requirements for dimensions, bending angle and changes in wall thickness shall be laid down in dependence of the procedure.

**B 4.7 Heat treatment****B 4.7.1 General**

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

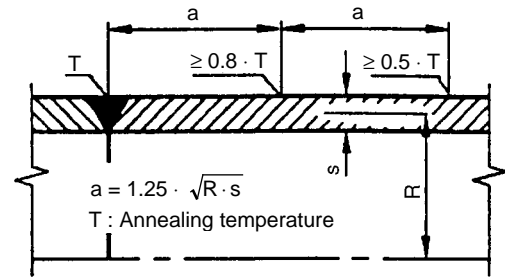
**B 4.7.2 Postweld heat treatment**

Upon final heat treatment, no welding work shall be performed on components requiring annealing after welding due to their wall thickness. Exceptions are only permitted by specific agreement with the authorized inspector.

**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  $2s$  (for DN greater than 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 with  $s$  smaller than or equal to 30 mm the temperature profile requirement is met if the heat input is provided to cover an area of  $8s$  and sufficient insulation beyond this width is provided.

(4) The heat input, insulation and 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 permanent set that is not permitted. 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-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 examinations 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 7168, general tolerance „coarse“ for unmachined parts
- b) to DIN 7168, general tolerance „average“ 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 checks during non destructive examinations
- 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 Field inspection by the authorized inspector.**

The in-process inspection shall be made randomly at fabrication stages to be fixed by the authorized inspector.

**B 4.10.3 In-process inspection by the manufacturer.**

(1) The essential in-process 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 examination
- 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 authorized inspector.

**B 4.10.4 Final inspection 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 examination (NDE) on welds**

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

(2) The performance of the test and inspections and the evaluation of the test results shall comply with AD-Merkblatt HP 5/3.

Materials	Ferrite $R_{p0.2 RT} > 370 \text{ N/mm}^2$		Ferrite $R_{p0.2 RT} \leq 370 \text{ N/mm}^2$	
			Austenite and combinations of austenitic/ferritic materials	
Non-destructive examinations	D (B) or US (B) <sup>2)</sup>	SCD	D (A) or US (A) <sup>3)</sup>	SCD
Examination of welds	25 % <sup>1)</sup>	25 %	5 % <sup>1)</sup>	Spot Checks
D = Radiography US = Ultrasonic examination SCD = Surface crack detection ( ) : = Test category to AD-Merkblatt HP 5/3  1) Not to be tested are a) nozzle welds $\leq \text{DN } 25$ b) Attachment welds (single-bevel, double - bevel groove welds, fillet welds) with a wall thickness $s < 15 \text{ mm}$ of the attaching component  2) double-wall technique permitted up to 40 mm 3) Not to be applied for austenite and combinations of austenitic/ferritic materials				

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

## Annex C

### 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).

Sicherheitskriterien KKW		Safety criteria for nuclear power plants. Notification of the Federal Minister of the Interior dated October 31, 1977 (BAnz. No. 206 of November 11, 1977)
RSK-LL		Reactor Safety Committee Guidelines for Pressurized Water Reactors, 3rd edition, October 14, 1981) BAnz. No. 69 dated 14 April 1982, Supplement 19/82) - Annexes to Chap. 4.2, dated April 25, 1979 (BAnz. No. 167a of September 6, 1979)
KTA 1408.1	(6/85)	Quality Assurance for Weld Filler Materials and Weld Additives for Pressure and Activity Retaining System in Nuclear Power Plants; Part 1: Suitability Testing
KTA 1408.2	(6/90)	Quality Assurance for Weld Filler Materials and Weld Additives for Pressure and Activity Retaining System in Nuclear Power Plants; Part 2: Manufacturing
KTA 3201.1	(6/90)	Components of the Reactor Coolant Pressure Boundary of Light Water Reactors; Part 1: Materials and Product Forms
KTA 3201.2	(3/84)	Components of the Reactor Coolant Pressure Boundary of Light Water Reactors; Part 2: Design and analysis
KTA 3201.3	(12/87)	Components of the Reactor Coolant Pressure Boundary of Light Water Reactors; Part 3: Manufacture
KTA 3205.1	(6/91)	Component Support Structures with Non-integral Connections; Part 1: Component Support Structures with Non-integral Connections for Components of the Reactor Coolant Pressure Boundary
KTA 3205.2	(6/90)	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	(6/91)	Pressure and Activity-Retaining Components of Systems outside the Reactor Coolant Pressure Boundary, Part 1: Materials
KTA 3211.3	(6/90)	Pressure and Activity-Retaining Components of Systems outside the Reactor Coolant Pressure Boundary, Part 3: Manufacture
KTA 3301	(11/84)	Residual Heat Removal Systems of Light Water Reactors
KTA 3401.2	(6/85)	Steel Containment Vessels; Part 2: Analysis and Design
KTA 3401.3	(11/86)	Steel Containment Vessels; Part 3: Manufacture
KTA 3401.4	(6/91)	Steel Containment Vessels; Part 4: In-service inspections
KTA 3601	(6/90)	Ventilation and Air Filtrations Systems in Nuclear Power Plants
DIN 1626	(10/84)	Welded circular unalloyed steel tubes subject to special requirements: technical delivery conditions
DIN 1630	(10/84)	High performance seamless circular unalloyed steel tubes; technical delivery conditions
DIN 1910, Part 1	(7/83)	Welding; concepts, classification of welding processes
DIN 2310, Part 2	(11/87)	Thermal cutting; determination of quality of cut faces
DIN 2462, Part 1	(3/81)	Seamless stainless steel tubes; dimensions: masses per unit length
DIN 2463, Part 1	(3/81)	Welded austenitic stainless steel; pipes and tubes; dimensions; conventional masses per unit length
DIN 7168, Part 1	(5/81)	General tolerances; linear and angular dimensions
DIN 7168, Part 2	(7/86)	General tolerances; shape and location
DIN 8563, Part 3	(10/85)	Quality assurance of welding operations; fusion welded joints on steel (except for steel welding): requirements, quality classes
DIN 17175	(5/79)	Seamless tubes of heat resistant steels; technical conditions of delivery

DIN 17177	(5/79)	Electric pressure-welded steel tubes for elevated temperatures; technical conditions of delivery
DIN 17441	(7/85)	Stainless steels; technical delivery conditions for plate and sheet, hot rolled strip, wire rod, drawn wire, steel bars, forgings and semi-finished products
DIN 25410	(10/87)	Nuclear facilities; component surface cleanliness
DIN 50049	(8/86)	Materials acceptance test certificates
DIN 50101, Part 1	(9/79)	Testing of metals; Erichsen cupping test on sheet and strip metal having a width of $\geq 90$ mm: thickness range = 0.2 mm to 2 mm
DIN 50101, Part 2	(9/97)	Testing of metals: Erichsen cupping test on sheet and strip metal having a width of $\geq 90$ mm: thickness range = over 2 mm up to 3 mm
DIN 50120	(E 2/88)	Testing of steel; tensile test on welded joints; fusion and pressure welded butt joints
DIN 50121	(E 4/89)	Testing of metallic materials; technological bending test on welded joints and weld claddings
DIN 50125	(3/86)	Testing of metallic materials; tensile specimens
DIN 50145	(8/75)	Testing of metallic materials; tensile test
DIN 50914	(6/84)	Testing the resistance of stainless steels to intercrystalline corrosion; copper sulfate/sulfuric acid method; Strauß test
DIN 54109, Part 3	(E 7/89)	Non-destructive testing; image quality of radiography; image quality levels for ferrous metals
DIN 54111, Part 1	(5/88)	Non-destructive testing; radiographic examination of metallic materials by X-rays; radiographing of fusion welded joints
AD B 13	(6/86)	Single-ply bellows expansion joints
AD HP 0	(7/89)	General principles of design, manufacture and associated tests
AD HP 2/1	(7/89)	Procedure qualification testing for joining processes; procedure qualification testing for welded joints
AD HP 5/1	(7/89)	Manufacture and testing of joints; principles of welding practice
AD HP 5/2	(7/89)	Manufacture and testing of joints; production testing of welds, testing of base metal after postweld heat treatment
AD HP 5/3	(7/89)	Manufacture and testing of joints; non-destructive testing of welded joints
AD HP 7/1	(7/89)	Heat treatment; general principles
AD HP 7/2	(7/89)	Heat treatment; ferritic steels
AD HP 7/3	(7/89)	Heat treatment; austenitic steels
AD HP 8/2	(7/89)	Testing of steel sections
AD W 0	(6/86)	General principle for materials
AD W 2	(1/90)	Austenitic steels
AD W 12	(8/88)	Seamless hollow components made from non-alloyed and alloy steels for pressure vessel steels
AD W 13	(11/87)	Forgings and rolled components made of non-alloyed and alloy steels
SEL 072	(12/87)	Ultrasonically tested plate; technical delivery conditions
SEL 096	(3/88)	Flat steel products, structural sections and bar steel with profiled section with improved forming capabilities normal to the product surface: technical delivery conditions
SEP 1915	(12/89)	Ultrasonic testing of steel tubes for longitudinal defects
SEP 1916	(12/89)	Non-destructive testing of fusion-welded ferritic steel tubes
SEP 1917	(10/80)	Non-destructive testing of electric pressure welded ferritic steel tubes
VdTÜV MB 1153	(11/88)	Guidelines for the qualification procedure of welding consumables