BAW
Bundesanstalt für Wasserbau

Kompetenz für die Wasserstraßen

BAWCode of Practice

Sealing of movement joints (MAB)

2025 Edition

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BAW Codes of Practice, Recommendations and Guidelines

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1 Scope of application

This Code of Practice applies to the sealing of movement joints between concrete components and between concrete and steel components in waterway engineering.

DIN 18197:2018-01 applies to the planning, product requirements, and execution of the sealing of movement joints between concrete components in the construction of new hydraulic structures, together with the regulations of the DIN 7865-1:2022-08 and DIN 7865-2:2022-08 series of standards, as well as DIN 18541-1:2021-01 and DIN 18541-2:2021-02 series referenced therein. Section 2 contains supplementary regulations. The above regulations apply mutatis mutandis to construction on existing buildings.

Section 4 applies to the planning, product requirements and execution of the sealing of movement joints between concrete components with attached clamping waterstops and to the sealing of joints between concrete and steel components using sealing tapes including the associated clamp construction.

If waterstops other than those specified in Sections 2, 4 and 5 are to be used (e.g. corner waterstops or expansion waterstops with a one-sided clamping construction for connecting new to existing concrete components), their suitability under the boundary conditions of waterway engineering must be demonstrated.

This can be done, for example, in accordance with the provisions of the MBO (Model Building Code) or through a European Technical Assessment (ETA), provided that the boundary conditions of waterway engineering are taken into account. Compression sealing profiles according to DIN 3764-1:2024-04 and DIN 3764-2:2024-04, which are described in Section 6, may only be used to seal horizontal joints against the ingress of unpressurised water and for covering.

The sealing of horizontal joints with joint sealing compounds is not the subject of this Code of Practice (see, for example, standard drawings for civil engineering structures (RiZ-ING 2024) and technical delivery conditions for joint fillers and joint filling systems in traffic areas (TL Fug-StB 24 2024)).

In the event of any contradictions, the provisions of the Code of Practice shall prevail over the reference standards. Dated references refer exclusively to the cited edition. At the time of application of the Code of Practice, it must be checked whether the cited version is still valid.

2 New construction, concrete components with embedded waterstops

2.1 Planning Principles

2.1.1 General

Sealing of movement joints must be planned and executed in such a way (if necessary in conjunction with the sealing system of the construction joints) that a closed and seamless sealing system is created. The sealing system consists of at least two sealing levels (“safety lines”). The number of independent sealing layers must be determined on a building-specific basis. As a rule, two sealing levels must be provided for locks and weirs. Replaceable waterstops with clamping structures according to Section 4 can also be provided as an additional sealing layer for movement joints in new construction.

When planning movement joints, the relevant expansion, compression and shear paths as well as the maximum water pressure (design water level) must be determined and used as a basis for the selection of the waterstop.

In the case of changes in direction in the sealing level (transition between lock chamber wall and base), the minimum bending radii according to DIN 18197:2018-01 must be observed.

Note: A design example for sealing joints in a concrete lock chamber can be found in Annex 1.

Joint closure tapes in accordance with DIN 7865-1:2022-08 and DIN 18541-1:2021-01 and compression sealing profiles in accordance with DIN 3764-1:2024-04 and DIN 3764-2:2024-04 may only be used to cover and seal against the ingress of unpressurised water in the area of the lock planing (between the vertical joint closure tapes).

Unless otherwise specified, joint filling panels made of extruded polystyrene (XPS) foam must comply with DIN EN 13164:2015-04 and be compatible with the waterstops.

If the required execution and waterstop system plans are prepared by the construction company, these must be submitted to the Client six weeks before the first installation and agreed upon with this same.

For each type of waterstop used, an excess length of 0.4 m must be allowed for later control tests.

Elastomeric waterstops in accordance with 7865-1:2022-08 must be used to seal movement joints. Waterstops made of thermoplastics according to DIN 18541-1:2021-01 are only permitted for sealing movement joints in subordinate building components (e.g. embankments, retaining walls) and as joint closure tape for horizontal joints.

If the waterstop is exposed to temperatures exceeding 40°C in use (e.g. joint closure tapes on a lock platform), only elastomer waterstops may be used. These must at least meet the requirements of exposure class EF2 according to DIN 7865-3:2020-08.

The exposure classes relevant for the respective joint situation must be determined by the Client in accordance with DIN 7865-3:2020-08.

The safety data sheets of the products must be submitted in accordance with Regulation (EC) No. 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH Regulation), Article 31 and Appendix II.

2.1.2 Structural requirements

The structural requirements according to DIN 18197:2018-01 must be taken into account during the planning. In deviation from these regulations, exposed ends of waterstops must be at least 500 mm above the design water level.

For waterstops with a central tube, this must be sealed with a closed-cell elastomer.

Leakage of the waterstop due to crack formation must be prevented by constructive crack-width-limiting reinforcement in the adjacent concrete components.

In the case of vertical movement joints (e.g. between two blocks of a lock chamber wall), according to DIN 18197:2018-01 (Figure 1), movement options must be created to limit the compression of the waterstop so that, with a nominal joint width of 20 mm, the joint width cannot be smaller than 15 mm.

2.1.3 Deformation stresses

In the case of large water pressure differences, such as in the half-frames of locks, the design should normally be executed for the area with the greatest water pressure (usually associated with a small resulting deformation) and the smallest water pressure (usually associated with the greatest resulting deformation), each in conjunction with the associated deformations.

2.1.4 Design principles and criteria for waterstop selection

In order to be able to attach waterstops with steel straps to the reinforcement, holes with a hole diameter of (4.0 ± 0.5) mm, an edge distance of (12.5 ± 1.0) mm and a distance between the holes of (125 ± 5) mm must be formed in the steel straps at the edge.

For elastomeric waterstops, the base polymer must be specified in accordance with DIN 7865-3:2020-08 depending on the exposure classes specified therein. Due to its more favourable behaviour under ozone exposure, the base polymer EPDM (ethylene propylene diene rubber) must be selected for exposure class EF9.

Joint closure tapes of type FAE according to DIN 7865-1:2022-08 or type FA according to DIN 18541-1:2021-01 may not be used due to the small distance between the formwork and the first row of locking anchors. If joint closure tapes according to DIN 7865-2:2022-08 or DIN 18541-2:2021-02 are to be used, they must be of the FAE type or FA type, but the distance between the formwork and the first stop anchor must be at least 60 mm.

If the ranges specified in the selection diagrams (see DIN 18197:2018-01, Figures 7 to 13) are exceeded, the suitability of the intended waterstop must be demonstrated by tests taking into account the design water level and the expected resulting deformation.

In slightly inclined and horizontal components such as lock bases, the waterstops to be concreted in must be V-shaped with an angle of approximately 15° upwards in order to avoid air accumulation below the sealing part of the waterstops. The reinforcement layout must be adjusted accordingly.

A design example for sealing joints between concrete components using embedded waterstops can be found in Annex 1.

2.1.5 Other planning guidance

Joint closure tapes in accordance with DIN 7865-1:2022-08 and DIN 18541-1:2021-01 may only be used to seal against the ingress of unpressurised water and soil (cover).

In the case of movement joints, joint closure tapes are not permitted in component areas subject to strong mechanical stress (e.g. due to ship impacts in vertical joints in lock chamber walls).

The formation of vertical movement joints in the area close to the surface of the component must be carried out taking Annex 2 into account.

For each type of waterstop used, an excess length of 0.4 m must be planned for later control tests.

2.2 Execution

2.2.1 Joint technology

For circumferential elastomer waterstops (e.g. for longitudinal ducts), the endless connection must be created by vulcanization.

Proof of qualification for carrying out construction site joints must be submitted to the Client at least two weeks before the joining date.

In order to enable the Client to monitor construction site joints, the Client must be informed of their execution at least two working days in advance.

The Contractor must prepare a test report for construction site joints in accordance with DIN 18197:2018-01, Appendix E, and submit it to the Client.

2.2.2 Handling on the construction site

No later than 8 weeks after the order has been placed, the Client must be provided with information on the base polymer of the sealing construction, the planned production lengths, samples of the intended waterstop types and, if applicable, a sample of the factory compound. The manufacturer of the waterstops and the place of manufacture must be stated.

The waterstops must be protected from contact with sharp-edged parts (reinforcement, tie wires, etc.) until they are cast in concrete.

Temporarily exposed waterstop ends must be protected from damage. The open central hoses must be sealed with closed-cell elastomer covers to protect against water ingress.

2.3 Quality assurance

For elastomer waterstops, an acceptance test certificate A according to DIN 7865-5:2022-08 is required. For this test certificate, the tested material and the waterstop must come from a delivery intended for the

respective construction site. The type and scope of the tests can be found in the tender documents (performance description). Acceptance test certificate A must be submitted to the Client at least 6 weeks before the installation date.

Sampling for control tests must be carried out in the presence of the Client and must be documented by the Contractor.

Immediately after delivery, the Contractor must compare the delivery notes with the specifications. The waterstops must be marked with the material abbreviations of the polymers. Compliance with the requirements of the specifications must be checked.

The Contractor must carry out, determine and document the activities listed in DIN 18197:2018-01, Appendix B. The construction site documentation must be submitted to the Client.

3 Strengthening of movement joints

3.1 General

To strengthen movement joints, the repair objective (e.g. permanent sealing, reducing water penetration or covering the joint) must first be determined. The exact location of leaks and defects is usually not possible to locate. The following methods for strengthening movement joints are described in more detail in the BAW R&D final report “Strengthening the movement joints of solid structures in waterway engineering” (Maisner 2016):

- Clamping waterstops: Fabric-reinforced Omega waterstop (GΩ) or steel cable-reinforced elastomer (steel cable reinforced clamping waterstop),
- Mortar-filled elastomer hose,
- Compression seal profiles according to DIN 3764-1:2024-04 (round profiles) or DIN 3764-2:2024-04 (box profiles)

In the case of a lock structure, the boundary conditions in Table 1 for the entire joint must be considered in order to select the repair method.

Table 1: Boundary conditions for the various repair systems

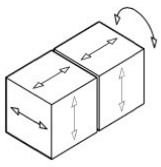
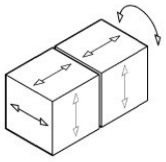
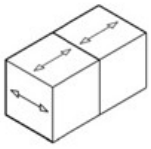
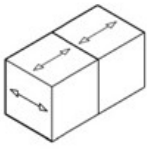
	Boundary condition	**Possible methods**			
		GΩ	**Steel cable reinforced clamping waterstop**	**Mortar-filled elastomer hose**	**Compression seal profiles**
1	Drainage possible?	x	x	x	x
2	Repairs required during operation?			x	
3	Repairs possible without closure		(x)	x	
4	Is a change of direction in the sealing layer necessary?	x	x		
5	Large joint movements?	x			
6	High pressure water up to 3.0 bar[1]?	x			
7	Is a force-fitting endless connection of the joint seal required?	x	x		
8	No preparation/cleaning of the joint flanks possible?	x	x	x	
9	Prevent the introduction of foreign substances (joint covering)	x	x	x	x
10	Water pressure on both sides?	x	x	x	

[1] According to DIN 7865-4:2019-12, functional tests should be carried out for sealing with clamping waterstops at water pressures above 3.0 bar.

(x) in combination with the “overdrilling of the joint” variant for the chamber walls.

The following Table 2 shows joint movement options for which the various repair systems can be used.

Table 2: Overview of methods and their movement options

Method	**Clamping waterstops**		**Mortar-filled elastomer hose**	**Compression sealing profiles**
	Fabric-reinforced Omega waterstop made of elastomer	Steel cable reinforced elastomer		
Movement options	GΩ 	Steel cable reinforced clamping waterstop* 	Mortar-filled elastomer hose 	Compression seal profiles 
	* Also in combination with “over-			

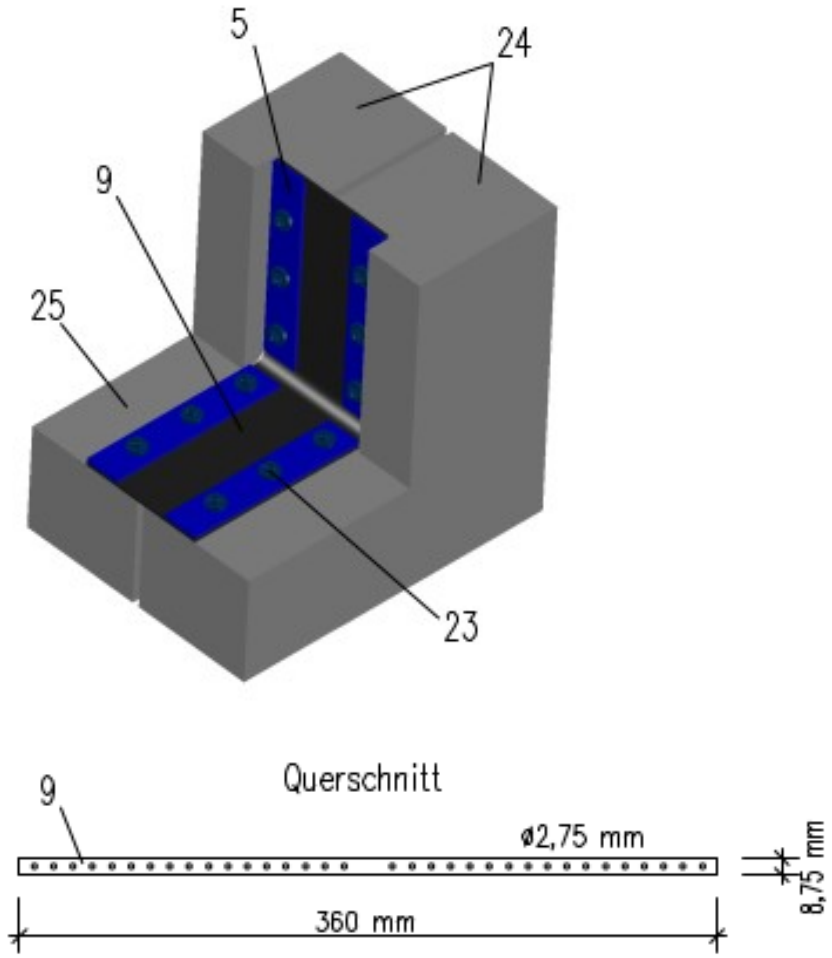
		drilling of the joint" for repairs under partial operation		

Excess lengths of 0.4 m of the elastomers must be allowed for later control tests.

In the case of lock chambers, repair methods using clamping structures have the disadvantage that the entire joint repair work requires drainage and a shipping barrier.

3.2 Joint repair with a steel cable reinforced clamping waterstop

Joint repair with a steel cable reinforced clamping waterstop has the advantage that no flange construction is required when changing direction in the sealing layer (see Maisner et al. 2015). Here steel cables run parallel to the joint. The following Figure 1 illustrates the sealing principle with the steel cable reinforced clamping waterstop.



Legend

5	5	Loose flange
9	9	Attached steel cable reinforced clamping watersto
23	23	Waterstop clamp construction with disc spring
24	24	Chamber wall

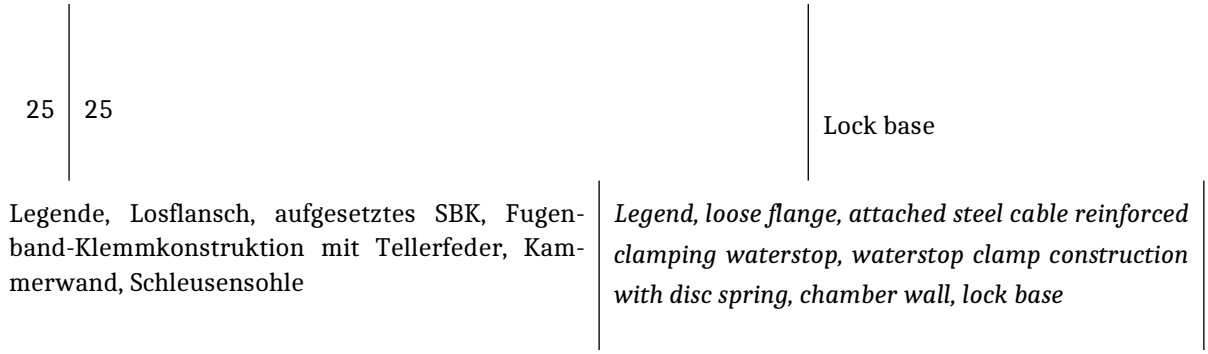


Figure 1: Change of direction in the sealing layer (top) and exemplary cross-section of a steel cable reinforced clamping waterstop (base)

The steel cable reinforced clamping waterstop shown as an example in Figure 1 (below) with a mass of 5.1 kg/linear m has a bending radius of 50 mm. In the corner, no flange construction is required due to the steel cables (tension beams) running along the longitudinal axis of the joint. There are no steel cables running across the joint gap. The steel cable reinforced clamping waterstop is attached directly to the subsequently processed concrete surface.

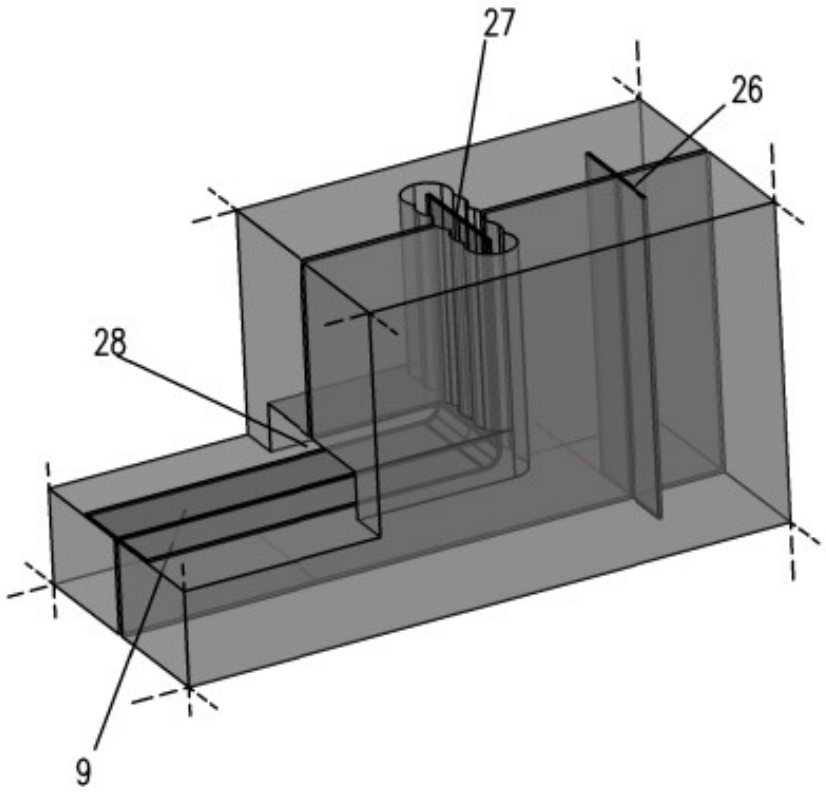
Details on the design of the clamping structure can be found in Annex 4.

The repair method can only be carried out if the lock chamber is drained and is suitable for horizontal and vertical joints.

Note: For planning purposes on federal waterways, the BAW can provide sample drawings and an exemplary general construction description for a wall height of 12 m.

3.3 Joint repair with the variant “combination of clamp construction and overdrilling of the joint”

With the steel cable reinforced clamping waterstop, a variant “overdrilling the joint in combination with a clamp construction” is possible for repairs during partial operation. The advantage of “overdrilling the joint” is that the vertical drilling of the borehole from the platform to underwater level can be carried out under lock operation. Draining the lock chamber is only necessary for the installation of the clamping structure in the area of the lock base and for the drilling of the inclined bore for connection to the vertical borehole. A commercially available fast-setting grout is used to fill the borehole. The following Figure 2 shows schematically the variant “Combination of clamping construction with the steel cable reinforced clamping waterstop and overdrilling of the joint”.



Legend

9	9	Attached steel c
26	26	Old waterstop
27	27	Overdrilled join ing waterstop
28	28	Removal of the stop

Legende, aufgesetztes Stahlseilbewehrtes Klemm-ugenband, altes Fugenand, überbohrte Fuge, einbetoniertes, Austritt des SBK	Legend, attached steel cable reinforced clamping waterstop, old joint edge, overdrilled joint, concreted, removal of the steel cable reinforced clamping waterstop

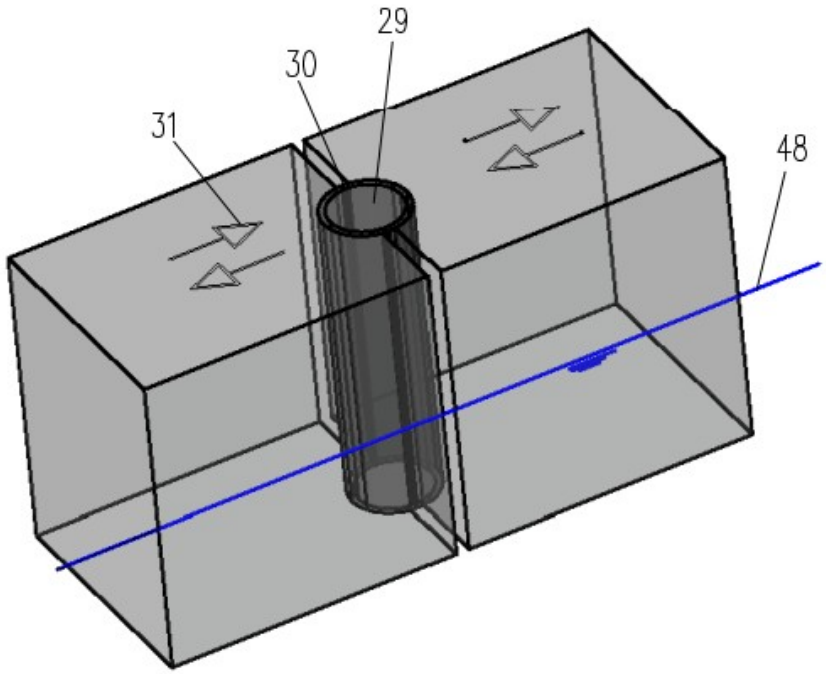
Figure 2: Variant "Combination of clamping construction with the steel cable reinforced clamping waterstop and overdrilling of the joint"

The repair method can be carried out under partial operation and is suitable for horizontal and vertical joints.

Note: For planning purposes on federal waterways, the BAW can provide sample drawings and an exemplary general construction description for a wall height of 12 m.

3.4 Mortar-filled elastomer hose

In the patented method “overdrilling the joint and inserting an elastomer hose”, the movement joint is first overdrilled with a core drilling machine (see Noritzsch 2006). An elastomer hose is then inserted and filled with a shrinkage-compensated mortar at a pressure of 8 to 10 bar. This results in a one-time expansion of the elastomer hose as a whole and a compression of the elastomer. In the event of a joint expansion, the sealing effect of the sealing element results exclusively from the elasticity and extensibility of the hose made of the special EPDM rubber. The wall compression on both sides must compensate for the occurring joint movement.



Legend

29 Mortar filling
30 Elastomer hose
31 Movement of the joint in X-direction
48 Water level in the lock chamber

Legende, Mörtelfüllung, Elastomer-Schlauch,Bewegung der Fuge in X-Rchtung, Wasserstand in der Schleusenkammer	Legend, mortar filling, elastomer hose, movement of the joint in X-direction, water level in the lock chamber

Figure 3: Mortar-filled elastomer hose

Before planning the repair work, the joint movement must be measured over a summer/winter cycle depending on the building temperature. When selecting the wall thickness of the elastomer hose and the required injection pressure of the mortar, the expected joint movements must be taken into account. The time of installation, the largest joint width is usually in winter and the smallest in summer, is also a parameter to be taken into account.

The repair method can be carried out during operation and is suitable for vertical joints.

3.5 Omega clamping waterstops

For clamping structures with Omega clamping waterstops (see DIN 7865-4:2019-12 Appendix A, Figure A.5), recesses must be planned in the concrete components to accommodate large movements. The clamping waterstop and the clamping construction must be designed for a water pressure of at least 3 bar. The clamping construction must be designed using disc springs in accordance with DIN EN 16983:2017-09 for a tension-holding force; the relaxation of the elastomer must be taken into account. The clamping structure must be re-tensioned to the required clamping force approximately 14 days after installation. The clamping construction must be designed in such a way that a visual inspection of the condition of the clamping waterstop is possible during use. In the case of clamping waterstop constructions with alternating water pressure, a steel pipe must be installed to protect the clamping waterstop from turning over (see DIN 7865-4:2019-12, Appendix A, Figure A.5). If there is a change of direction in the sealing plane, clamp flanges for curves with a minimum radius of 400 mm must be installed. The required loop length of the clamping waterstop must be determined according to DIN 7865-4:2019-12 Appendix B.

Clamping constructions with a raw rubber sealing layer are not permitted.

The metallic materials of the clamping construction must be protected against corrosion with a factory-applied coating. For corrosion protection, products from the “List of approved systems I for freshwater [Im1]” for steel hydraulic structures (Federal Waterways Engineering and Research Institute 2022a) to use. For contact with salt, brackish water and soil, the “List of approved systems II [Im2/Im4, Im3]” applies (Federal Waterways Engineering and Research Institute 2022b). A coating thickness of at least 500 µm must be maintained.

For elastomer Omega clamp joints, the requirements of DIN 7865-4:2019-12 according to Table 1 (without fabric insert) and Table 2 (with fabric insert) apply. For higher water pressures (over 3.0 bar), functional tests should be carried out for the case of application.

4 Sealing of joints between concrete components and between concrete and steel components with attached sealing structures

4.1 Planning Principles

4.1.1 General

The following planning principles apply to new construction and repair work for the sealing of joints between concrete components using clamping waterstops and for the sealing of joints between concrete and steel components using sealing tapes, each with the associated clamping constructions.

With regard to the determination of the resulting deformation, the specification of the nominal joint width and the specification of the design water level, the regulations of DIN 18197:2018-01 apply accordingly.

No later than 8 weeks after the order has been placed, the Client must be provided with information on the base polymer of the sealing construction, the planned production lengths, a sample of the clamping waterstop or the sealing tape and, if applicable, a sample of the factory compound. The manufacturer of the clamping joint or sealing tape and the place of manufacture must be stated.

The safety data sheets of the products must be submitted in accordance with Regulation (EC) No. 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), Article 31 and Appendix II.

The sealing effect of clamping joints or sealing tapes must be permanently guaranteed by a tension-retaining clamp. To ensure a tension-retaining clamping, disc springs must be used in accordance with DIN EN 16983:2017-09 .

The metallic materials of the clamping construction must be protected against corrosion with a factory-applied coating. For corrosion protection, products from the “List of approved systems I for freshwater [Im1]” for steel hydraulic structures (Federal Waterways Engineering and Research Institute h 2022a) must be used. For contact with salt, brackish water and soil, the “List of approved systems II [Im2/Im4, Im3]” applies (Federal Waterways Engineering and Research 2022b). A coating thickness of at least 500 µm must be maintained.

The tolerances for the linear dimensions of the flange construction shall be specified in accordance with DIN ISO 2768-1:1991-06.

For clamping constructions with Omega clamping waterstops, see Section 3.5.

For trough seals of canal bridges (joints in canal overpasses) see DIN 7865-4:2019-12 Figure A.4.

For clamping joints or sealing tapes made of elastomer, the requirements of DIN 7865-4:2019-12 according to Table 1 (without fabric insert) and Table 2 (with fabric insert) apply.

Clamping constructions with a raw rubber sealing layer are not permitted.

4.1.2 Design principles and requirements

Clamping joint or sealing tapes must comply with tolerance class E3 according to DIN ISO 3302-1:2018-06. The manufacturing tolerance for thickness is ± 10% (absolute). For tolerances exceeding the nominal dimensions of DIN ISO 3302-1:2018-06, Table 2, the tolerances of DIN EN ISO 14890:2013-06 apply.

Clamping joint or sealing tapes must meet the requirements of DIN 7865-4:2019-12 according to Table 1 (without fabric insert) and Table 2 (with fabric insert) in the expansion area. When submitting an offer to the tender, a data sheet from the manufacturer must be requested to demonstrate compliance with the requirements set out in Table 1 or 2.

4.2 Execution

The clamping construction must be re-tensioned according to the manufacturer's instructions for the clamping joint or sealing tape.

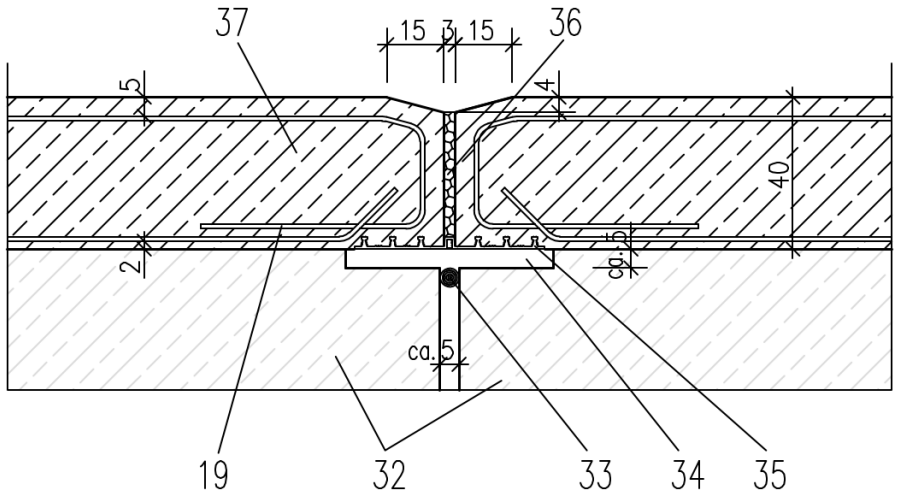
5 Sealing of connecting joints between existing and new concrete

5.1 General

The use of a raw rubber sealing layer between the old concrete and the waterstop is not permitted. For the installation of a fixed flange construction in the existing structure, a flat concrete surface must be created. The selection of the waterstop for the joint closure to the movement joint in the existing concrete must be made in accordance with DIN 18197:2018-01. The design water pressure results from the maximum possible water level difference taking into account the revision case.

5.2 Connection of joints to facing shells made of in-situ concrete or shotcrete

The existing movement joints are incorporated into the new facing shell. An external elastomer waterstop in accordance with DIN 7865-1:2022-08 is placed over the existing movement joint between the facing shell and the old concrete. The following Error: Reference source not found shows an example of the connection of a facing shell to the existing concrete. Information on the required component thickness and the required distance between the anchor ribs and the reinforcement as well as on installation in horizontal or slightly inclined components can be found in DIN 18197:2018-01, installation examples Figures 16 to 23.



Legend

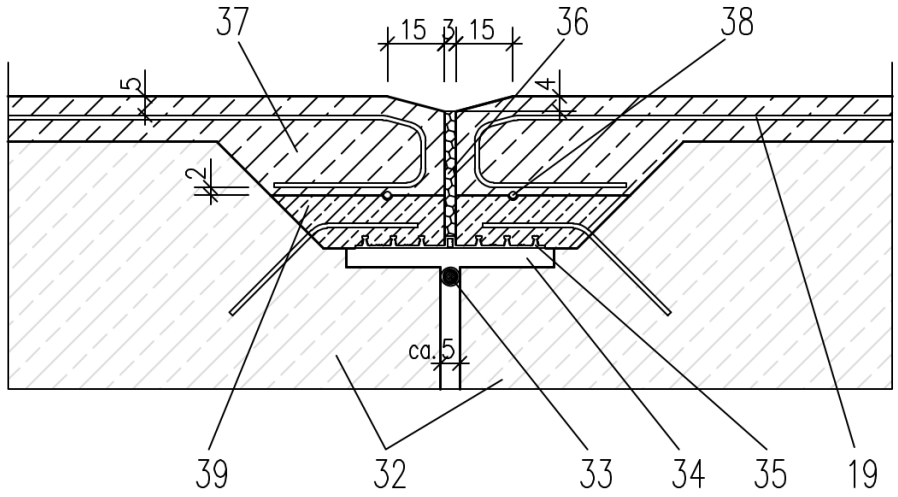
19 Reinforcement
32 Old concrete
33 Tubing
34 Smooth coating (levelling layer of mortar) or smoothed old concrete surface
35 Elastomer waterstop according to DIN 7865-1:2022-08, form AM
36 Joint filler plate
37 Chamber wall facing shell in-situ concrete

Legende, Bewerung, Altbeton, Abschlauchung, Glattstrich (Ausgleichschicht aus Mörtel) oder ggeglättete Altbetonoberfläche, Elastomer-Fugen-	*Legend, assessment, old concrete, hoses, smooth coating (levelling layer of mortar) or smoothed old concrete surface, elastomer waterstop according to*

band nach DIN 7865-1:2022-08 der For AM, Fugenfüllplatte, Kammerwand-Vorsatzschale Ortbeton	*DIN 7865-1:2022-08 of For AM, joint filling plate, chamber wall facing shell in-situ concrete*

Figure 4: Movement joint facing shell in-situ concrete/old concrete (dimensions in cm)

For the connection of joints to existing concrete and shotcrete, additional work steps are required for the installation of a waterstop of the form AM 500 according to DIN 7865-1:2022-08 by contrast with the connection between facing shell and existing concrete. A niche must be removed in the area of the joint for the installation of the waterstop. In the niche, the waterstop is fixed to a levelling layer of mortar and encased in concrete using self-compacting concrete (SCC) or grouting mortar in accordance with the DAfStb guideline (2019) “Production and use of cement-bound grouting concrete and grouting mortar”. To ensure watertightness between the SCC and the shotcrete, injection hoses must be installed on both sides of the movement joint in accordance with the DBV Code of Practice “Injection hose systems and swellable inserts for construction joints” (2020). When concreting the SCC, triangular tapes must be inserted to secure the position. The construction joint between SCC and shotcrete is according to ZTV-W LB 219 (2024). Information on the use of injection hose systems can be found in the DBV Code of Practice and Hohmann (2022) . The following Figure 5 shows an example of the connection of a shotcrete facing to the existing concrete.



Legend

Reinforcement
Old concrete

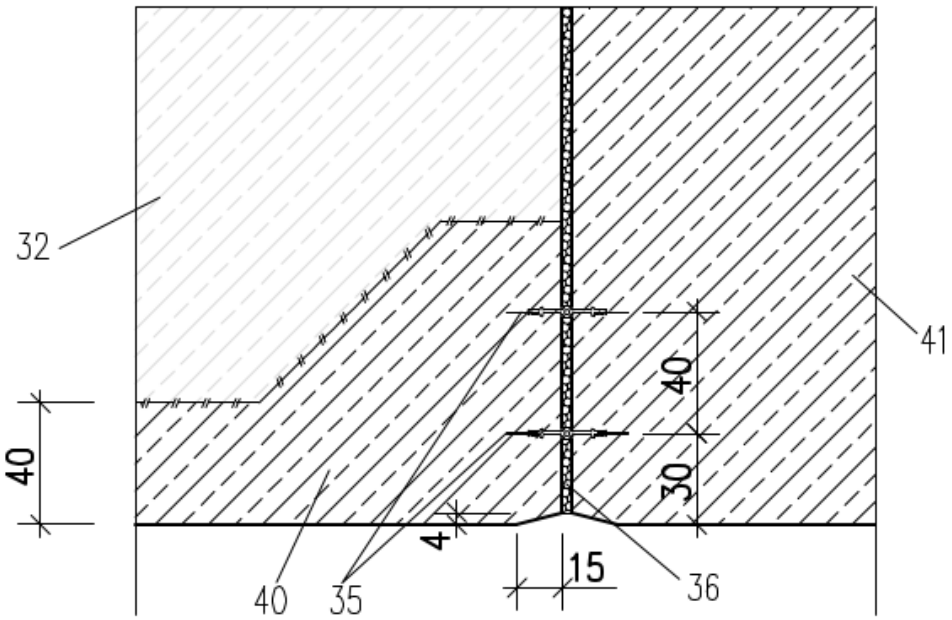
Smooth coating (levelling layer of mortar) or smoothed old concrete surface
Elastomer waterstop according to DIN 7865-1:2022-08, form AM 500
Joint filler plate
Chamber wall shotcrete
Injection hose
SCC or grouting mortar

Figure 5: Movement joint shotcrete facing shell/old concrete (dimensions in cm)

The material properties of the elastomer waterstop must comply with DIN 7865-2:2022-08.

The water-side joint closure in facing shells and shotcrete shall be carried out in accordance with Annex 2.

If the old base needs to be connected to the new base when extending a lock, a joint transition must be created using elastomer waterstops in accordance with DIN 7865-1:2022-08. In the case of the extension of lock chamber walls, the old concrete in the area of the block joint must be removed to a depth of at least 1 m in order to achieve sufficient space for the waterstop formation. The new concrete block (chamber wall facing shell) must be connected to the old concrete with reinforcement, just like the facing shell. The following Figure 6 shows an example of the connection of joints in the case of a lock extension (old wall / new wall) with in-situ concrete. The same procedure applies to the lock base.



Legend

Old concrete
Elastomer waterstop according to DIN 7865-1:2022-08, form FMS
Joint filler plate
Chamber wall facing shell
Lock extension (new in-situ concrete)

Figure 6: Example of lock extension with in-situ concrete, old wall / new wall (dimensions in cm)

Legende, Altbeton, Elastomer-Fugenband nach DIN 7865-1:2022-08 dr Form FMQ, Fugenfüllplatte, Kammerwand-Vorsatzschale, Schleusenverlängerung (neuer Ortbeton)	Legend, old concrete, elastomer waterstop according to DIN 7865-1:2022-08 dr Form FMQ, joint filling plate, chamber wall prefabricated shell, lock extension (new in-situ concrete)

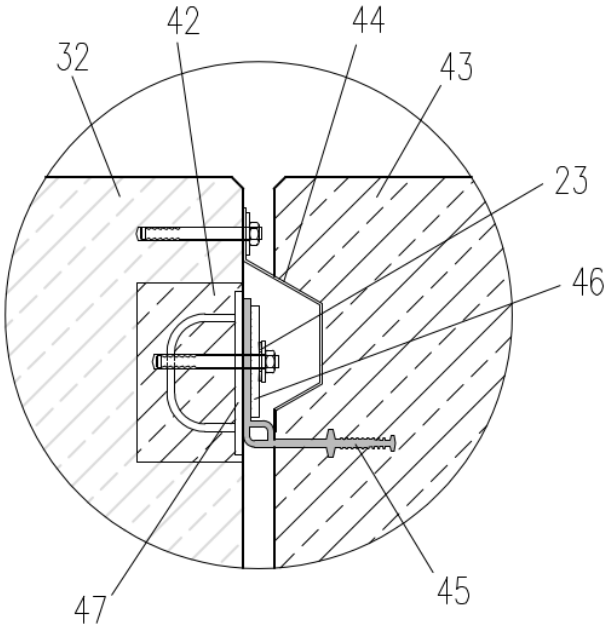
5.3 Connection to the existing concrete with clamping structures cast into one side

There are currently no regulations regarding the form (composition) and use of clamping waterstops that are to be embedded in concrete on one side. For the application, consent in each individual case is re-

quired. The elastomer waterstop must comply with the material properties according to DIN 7865-2:2022-08.

In the case of one-sided clamping constructions for sealing connecting joints, in the case of horizontal components in new concrete, it must be ensured that the leg of the clamping waterstop to be embedded in concrete is installed in a V-shape with an angle of at least 15° upwards in order to avoid air accumulation during concreting.

The old concrete must be removed to a depth of at least 1 m to create sufficient space for the fixed flange construction. The new concrete seal for the installation of the fixed flange must be connected to the old concrete with reinforcement. The holes for the loose flange must be drilled according to the template using the waterstop holes as a guide. On-site joints must be made by vulcanization. Disc springs according to DIN EN 16983:2017-09 must be used for tension-retaining clamping. The following shows an example of the connection to the old concrete with an angled waterstop embedded and clamped on one side.



Legend

23	Tension-holding clamping with disc springs
32	Old concrete
42	Removal for fixed flange installation
43	New construction
44	Clamping protection profile
45	Clamped and one-sided concreted angle waterstop made of elastomer
46	Loose flange
47	Fixed flange with reinforcement connection

Legende, Spannungqhaltende Klemmung mit Tellerfedern, Altbeton, Abtrag für Festflanscheinbau, Neubau, Klemmschützprofil, Geklemmtes und einseitig einbetoniertes Winkel-

Legend, tension-retaining clamping with disc springs, old concrete, removal for fixed flange installation, new construction, clamping protection profile, clamped and one-sided concreted angle

Fugenband aus Elastomer, Losflansch, Festflansch mit Bewehrungsanscluss	*waterstop made of elastomer, loose flange, fixed flange with reinforcement connection*

Figure 7: Example wall, connection old concrete/new building with angle waterstop embedded in concrete on one side

6 Subsequent covering of joints with compression sealing profiles

For the subsequent covering of horizontal joints (e.g. chamber wall platform) and vertical joints, compression sealing profiles made of elastomer according to DIN 3764-1:2024-04 (round profiles) or DIN 3764-2:2024-04 (box profiles) can be installed. The profile diameter must be adapted to the joint width and the expected component movements.

For successful installation, the joint flanks must be parallel in depth up to twice the joint width and the flanks must be flat and free of contamination. Since the joint width and depth must be constant over the entire length of the joint, it may be necessary to recut it with a diamond saw blade. The compression sealing profile must be installed according to the manufacturer's instructions. The profile is installed by compressing it and then pressing it into the joint. The positional stability of the profiles must be visually checked annually.

Information on factory production control of compression sealing profiles can be found in DIN 3764-3:2024-04.

7 Further information on quality assurance

Object-specific external monitoring of the production of the clamping joint or sealing tape may need to be agreed in the construction contract and must be carried out on the basis of DIN 18200:2021-04.

For each type of waterstop/seal used, an excess length of 0.4 m must be planned for later control tests.

The regulations regarding the decrees WS 12/5257.13/3 (VkBl. 2020 and VkBl. 2023) must be observed.

Annex 3 contains a checklist for construction supervision by the Client.

8 Literature/Complex of rules

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DIN 3764-3:2024-04: Design, elastomer compression sealing profiles for sealing or covering joints in concrete and masonry – Part 3: Factory production control.

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DIN 7865-2:2022-08: Elastomer waterstops for sealing joints in concrete, Part 2: Material requirements and testing.

DIN 7865-3:2020-08: Elastomer waterstops for sealing joints in concrete, Part 3: Scope of use.

DIN 7865-4:2019-12: Elastomer waterstops for sealing joints in concrete, Part 4: Interchangeable clamping waterstops

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DIN 18197:2018-01: Sealing of joints in concrete with waterstops

DIN 18200:2021-04; Assessment of conformity for construction products - Factory production inspection, third-party monitoring and certification

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DIN 18541-2:2021-02; Thermoplastic waterstops for sealing joints in concrete – Part 2: Material requirements and testing

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Annex 1: Design example for sealing joints between concrete components using embedded waterstops according to Section 2

Informative example for the design of an internal elastomeric waterstop to be cast in concrete in the movement joint between two blocks of a lock chamber with a change in direction in the sealing plane at the base/wall transition (horizontal/vertical).

Boundary conditions:

Exposure class EF 9 for hydraulic structures according to DIN 7865-3:2020-08, Table A.1

Water pressure [bar]: W_s = 1.4 bar

Joint width [mm]: ω_{norm} = 20 mm

Relative deformations in the joint in the global coordinate system (see DIN 18197:2018-01, Figure 2) for the structure [mm]:

ν_x = 15 mm

ν_y = 25 mm

ν_z = 5 mm

Table 1: Deformations of the waterstop in the local coordinate system base or wall

	ν_x	n_y	ν_z
Waterstop in the base [mm]	15	25	5
Waterstop in the wall [mm]	15	5	25

Calculation of the resulting deformation for the waterstop in the base:

$$\nu_r = \sqrt{\nu_x^2 + \nu_y^2 + \nu_z^2} = \sqrt{15^2 + 25^2 + 5^2} = 29,6\,mm$$

Calculation of the resulting deformation for the waterstop in the wall:

$$\nu_r = \sqrt{\nu_x^2 + \nu_y^2 + \nu_z^2} = \sqrt{15^2 + 5^2 + 25^2} = 29,6\,mm$$

Determination of the permissible shear stress of the waterstop:

Sole:

ν_y = 25 mm > ω_{norm} = 20 mm

Wall:

ν_y = 5 mm < ω_{norm} = 20 mm

Since the shear stress of the waterstop in the area of the base is greater than that for a joint with the joint width ω_{norm} = 20 mm permissible shear movement (ν_y = 5 mm ≤ ω_{norm} = 20 mm), additional measures must be taken according to DIN 18197:2018-01, Figure 1. According to DIN 18197:2018-01, measures such as constructive precautions with a deformation chamber (see Figure 1a), a waterstop with a central hose sheath and integrally formed hollow chamber (Figure 1b) or an increase in the joint width are necessary.

Selection of the waterstop:

For a load of 1.4 bar and a resulting deformation of 29.6 mm, an elastomer waterstop of the form FMS 400 according to DIN 7865-1:2022-08 can be selected according to DIN 18197:2018-01, Figure 11. According to DIN 7865-3:2020-08, Table A.1, the base polymer EPDM is chosen due to exposure class EF 9 (for hydraulic structures). The waterstop must also be ordered with a central hose sheath and moulded hollow chamber:

Waterstop DIN 7865-1,2:2022-08 FMS 400 EPDM MU and DIN7865-3:2020-08 EF9

NB (1): The abbreviation MU stands for an injection-moulded (extruded) centre tube sheath.

NB (2): In the case of large water pressure differences, the design must be carried out for the area with the highest water pressure (usually associated with a small resulting deformation) and the lowest water pressure (usually associated with the largest resulting deformation). For the purposes of the example, a constant deformation was assumed at every point in the area of the movement joint.

Annex 2: Formation of vertical movement joints in the area close to the component surface

Comments: The following statements are based on the BAWBrief 3/2008 (Bödefeld et al. 2008), in which the overall problem is presented in detail.

1. General

When forming movement joints (also called “space joints” or “expansion joints” in construction) of lock chamber walls and similar components in the area of the water- and earth-side component surfaces, the following aspects, among others, must be taken into account:

1. Avoidance of edge spalling due to mechanical stress, especially from ship approach
2. Avoiding the entry of foreign substances that could impair the functionality of the movement joint.

In order to avoid edge spalling due to mechanical stress from ship approach, bevels of the adjacent component surfaces are preferably carried out on waterway structures. The extent of these bevels has been handled very differently in the past. The protection of the edges of the components adjacent to the movement joint using armouring, for example by means of steel profiles, has so far only very rarely been implemented on waterway structures.

To prevent the entry of foreign substances into the movement joint gap, so-called joint closure tapes were often used on waterway structures. In some cases, compression seals were used instead of joint closure tapes, which were pressed or hammered into the movement joint gap after the components had been completed. In many buildings, sealing of the joint gap on the water side by means of sealing elements was completely omitted; the joints were left open up to the actual sealing level or were protected at least to a certain extent against the penetration of foreign substances by leaving joint inserts (mostly hardboard). The collocation of joint closure tapes, which are integrated into the concrete via locking anchors, is often associated with a weakening of the corner areas of the adjacent components and resulting damage. Compression profiles have generally proven to be of little durability in terms of their positional stability. The extent to which protection against the ingress of foreign substances is actually necessary for the functionality of the movement joint and the actual sealing element (waterstop) certainly depends on the boundary conditions. A more local entry of foreign substances on the water side into the movement joint area up to the sealing level is likely to be far less critical than the complete filling of the corresponding area on the earth backfill side. Damage to the actual sealing element due to the ingress of foreign matter has not been reported to date.

Remark: The joint closure tapes mentioned do not have a sealing function against the penetration of water and prevent the entry of foreign substances into the joint by covering it.

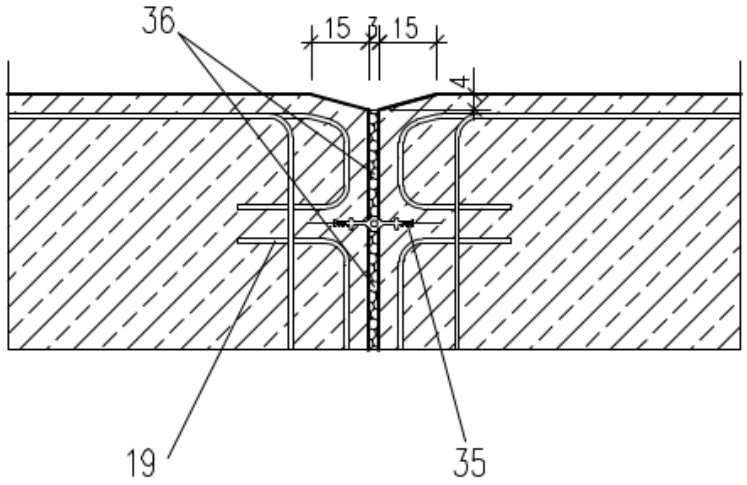
Due to various problems (in particular edge spalling on the waterside wall surfaces of lock chamber walls; compaction problems, concrete spalling, etc. in the case of joint closure tapes), the experience within the Waterways and Shipping Administration with the formation of movement joints in the near-surface area was compiled in 2007/2008 and proposals for standardised procedures were developed. These suggestions are presented below.

Remark: Instructions for the repair of concrete components of hydraulic structures can be found in ZTV-W LB 219 (2024).

2. Formation of movement joints in the waterside area

Two suggestions for the design of the water-side movement joint closure are outlined below. In both cases, the required concrete cover according to ZTV-W LB 215 (2024) of c_{min} = 50 mm / c_{nom} = 60 mm without swivelling the reinforcement. To avoid possible load application points ("underhooks"), a smooth transition from the edge bevel to the horizontal edge protection of the planing should be formed.

The design according to Figure 1 with pronounced bevel should be used in areas where significant mechanical impact is to be expected, particularly from ship approach.



Legend

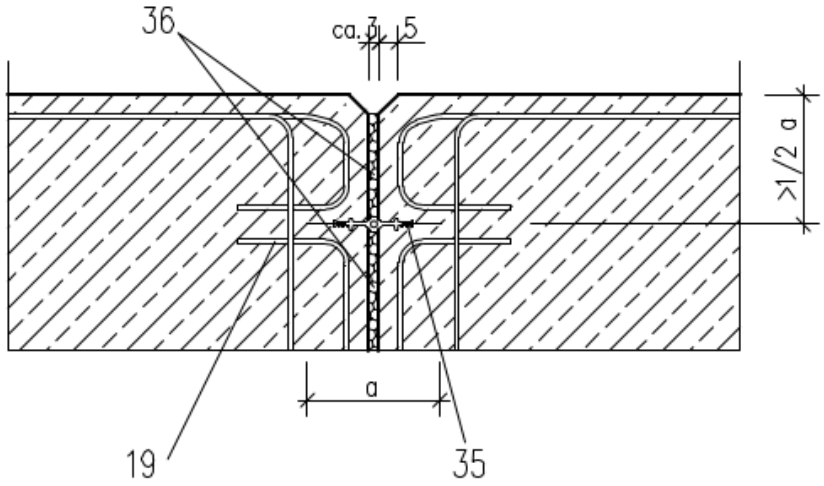
19	Reinforcement
35	Elastomer waterstop according to DIN 7865-1:2022-08, form FMS
36	Joint filler plate

Legende, Bewehrung, Elastomer-Fugenband nach DIN 7865-1:2022-08 der Form FMS, Fugenfüllplatte	*Legend, reinforcement, elastomer waterstop according to DIN 7865-1:2022-08 of form FMS, joint filling plate*

Figure 1: Waterside joint closure in case of intensive mechanical impact (e.g. due to ship approach) (dimensions in cm)

The pronounced bevel shown in Figure 1 ensures efficient protection of the joint edges against impact by ships. The length of the bevel of 150 mm allows the required concrete cover to be maintained on all concrete surfaces without swivelling the reinforcement. When designing the surrounding reinforcement for the waterstop, this must be ensured by selecting the appropriate reinforcement diameter and bending roller radius.

The version shown in Figure 2 with moderate bevel is characterised by its simple practical implementation (including inserting commercially available profiles into the formwork). However, it should only be used if intensive mechanical impact, for example as a result of a ship's approach, can be excluded for the duration of use.



Legend

19	Reinforcement
35	Elastomer waterstop according to DIN 7865-1:2022-08, form FMS
36	Joint filler plate

Legende, Bewehrung, Elastomer-Fugenband nach DIN 7865-1:2022-08 der Form FMS, Fugenfüllplatte	*Legend, reinforcement, elastomer waterstop according to DIN 7865-1:2022-08 of form FMS, joint filling plate*

Figure 2: Water-side joint closure without significant mechanical impact (dimensions in cm)

In both variants, a joint closure tape is omitted due to the associated disadvantages (weakening of the concrete in the corner area of the adjacent components). The associated risks (impairment of the functionality of the movement joint due to the ingress of foreign matter; endangerment of the actual joint seal) can be considered negligible due to the positive experience with this construction method in numerous waterway structures.

3. Formation of movement joints in the ground-side area

In contrast to the water-side wall surfaces, the protection of the movement joint gap from the full-surface ingress of foreign substances is of utmost importance for the earth-side wall surfaces. The ingress of foreign matter will be more intense here, among other things due to the compaction of the soil introduced after completion of the component, than is the case in the waterside area during the use phase.

For the earth-side movement joint closure, it is therefore proposed to break the vertical edges of the components (e.g. chamber wall blocks) using triangular tapes, as is customary in construction. In addition, measures should be taken to protect against the ingress of foreign substances, such as

- the collocation of steel or aluminium sheets over the movement joint, which are attached to a chamber wall block on one side, after completion of the solid construction and before installation of the soil backfill
- analogous to the arrangement of “dimpled foil” over the movement joint
- the concreting of an external waterstop (e.g. form AM 500 according to DIN 7865-1:2022-08).

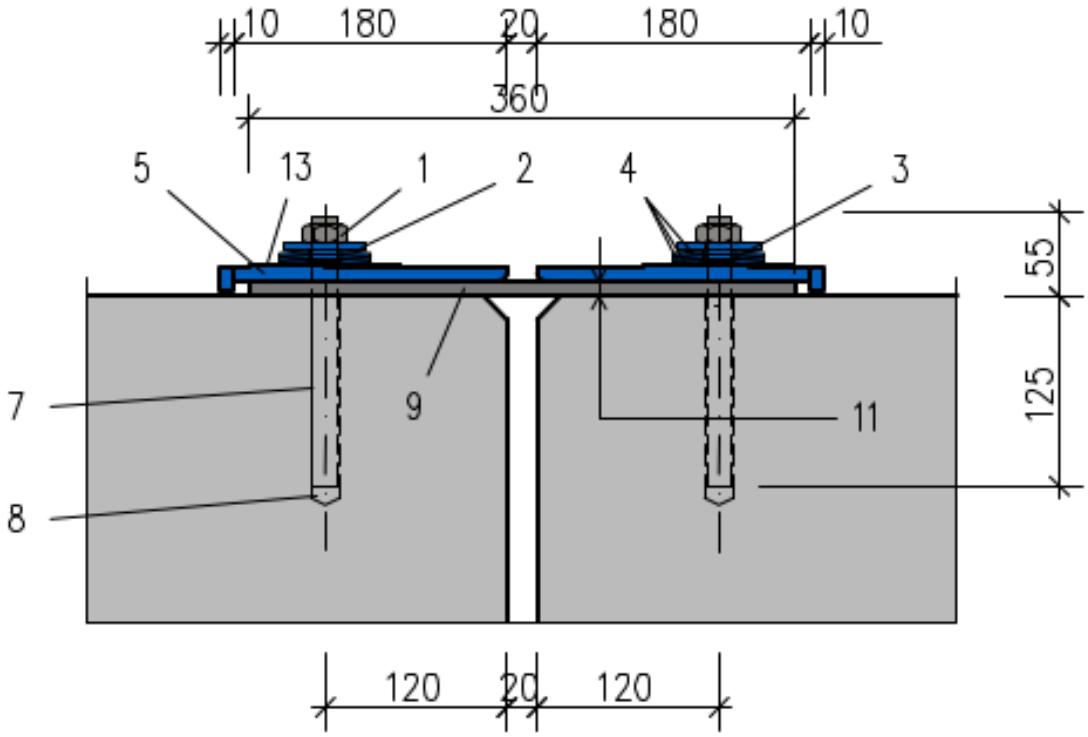
Annex 3: Checklist for construction supervision by the Client

1. Submission of the execution and waterstop system plans by the Contractor at the start of the construction project (if to be provided by the Contractor).
2. Information on the designation, base polymer, manufacturer and place of manufacture of the intended waterstop types no later than 8 weeks after placing the order.
3. Information on production lengths and submission of samples of the intended waterstop types as well as, if applicable, samples of factory compounds before installation begins.
4. Submission of the acceptance test certificate A according to DIN 7865-5:2022-08 before the installation of elastomer waterstops.
5. For waterstops according to DIN 7865-1:2022-08 with steel plates, the edge distances and diameters of the holes in the steel plates must be checked and documented.
6. Coordination of control tests with the BAW in order to ensure timely submission of test results before the installation date (time required for control tests is usually 10 weeks).
7. Check whether joint insert plates are used in accordance with the tender.
8. Maintain a minimum distance of 20 mm between the waterstop and the reinforcement.
9. Visual inspection of the waterstops before concreting for correct position, position stability and contamination or encrusted old concrete.
10. Submission of construction site documentation in accordance with DIN 18197:2018-01, Appendix B, by the Contractor in the case of the sealing of movement joints in accordance with Section 2.
11. Submission of the test report to be prepared by the Contractor in accordance with DIN 18197:2018-01, Appendix E, when executing construction site joints.

Remark:

The BAW's control tests on the supplied waterstops are carried out step by step and include, in the first step, an image analysis of the shape and dimensions, in the next step a chemical analysis of the base polymers and finally the physical material test.

Annex 4: Examples of the clamp construction with the attached steel cable reinforced clamping waterstop

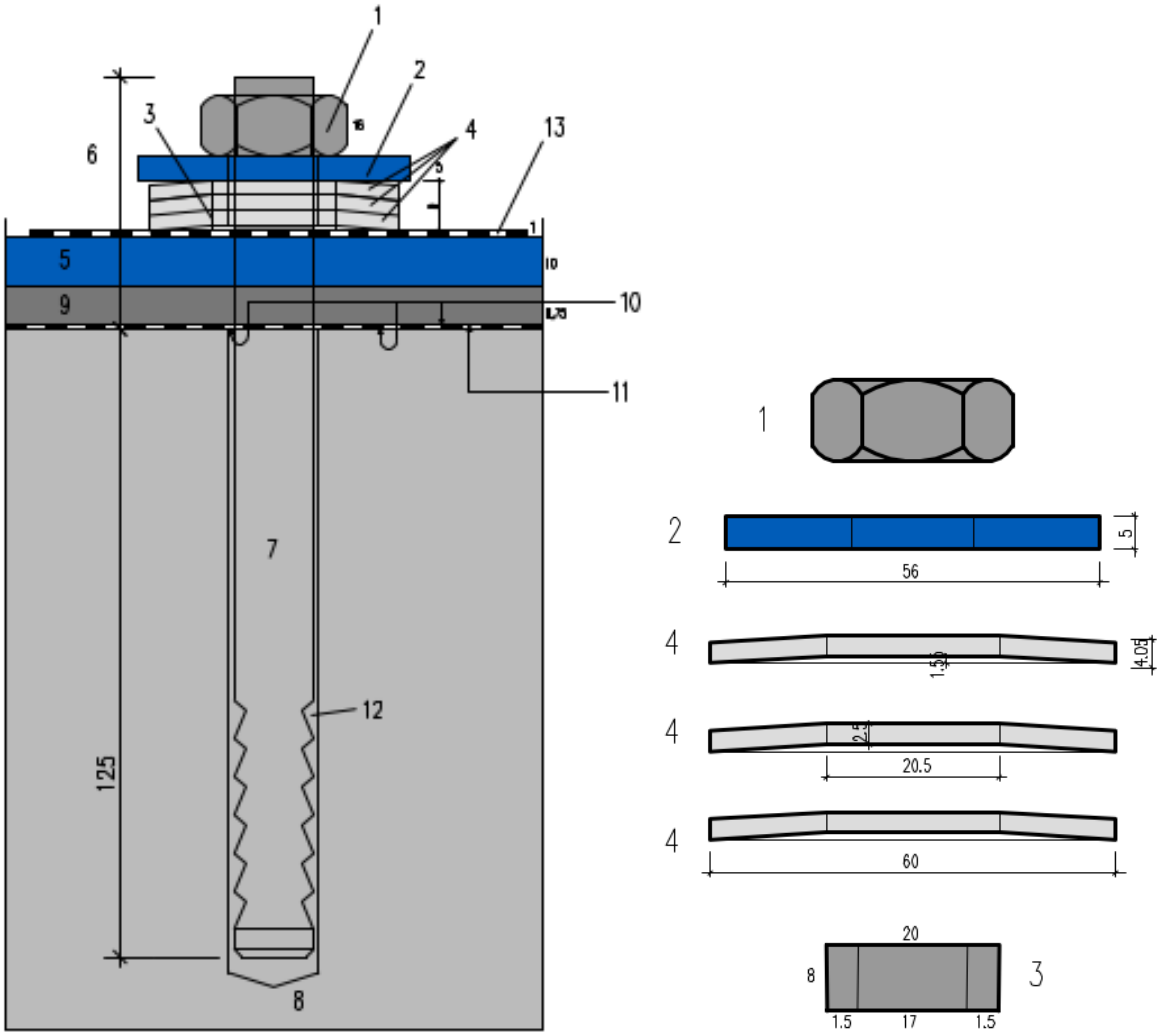


Legend

1 M16 nut
2 Washer
3 Plastic bushing
4 Disc springs
5 Flange 180x 10x ≤1000 and sheet metal 16x10x ≤1000
7 Anchor rod
8 Anchor borehole
9 Steel cable reinforced clamping waterstop
11 Swelling fleece
13 Sealing tapes

Legende, Mutter M16, Unterlegscheibe, Kunstoffbuchse, Tellrfedern, Flansch und Blech,Ankerstange, Ankerbohrung, Stahlseilbewehrts Klemm-Fugenband (SBK), Quellvlies, Dichtstrefen	*Legend, M16 nut, washer, plastic bushing, disc springs, flange and sheet, anchor rod, anchor borehole, steel cable reinforced clamping waterstop, swelling fleece, sealing tape*

Figure 1: Steel cable-reinforced clamping waterstop, clamp construction in the non-accessible area of the base without joint cover (Dimensions in mm)



Legend

1 M16 nut
2 Washer
3 Plastic bushing
4 Disc springs
5 Flange 180x 10x ≤1000 and sheet metal 16x10x ≤1000
6 Dowel projection for construction with cover = 75 mm (without = 55 mm)
7 Anchor rod
8 Anchor borehole
9 Steel cable reinforced clamping waterstop
10 Water-swellable sealant
11 Swelling fleece
12 Injection mortar
13 1 mm thick sealing tape made of TPE or plastic film

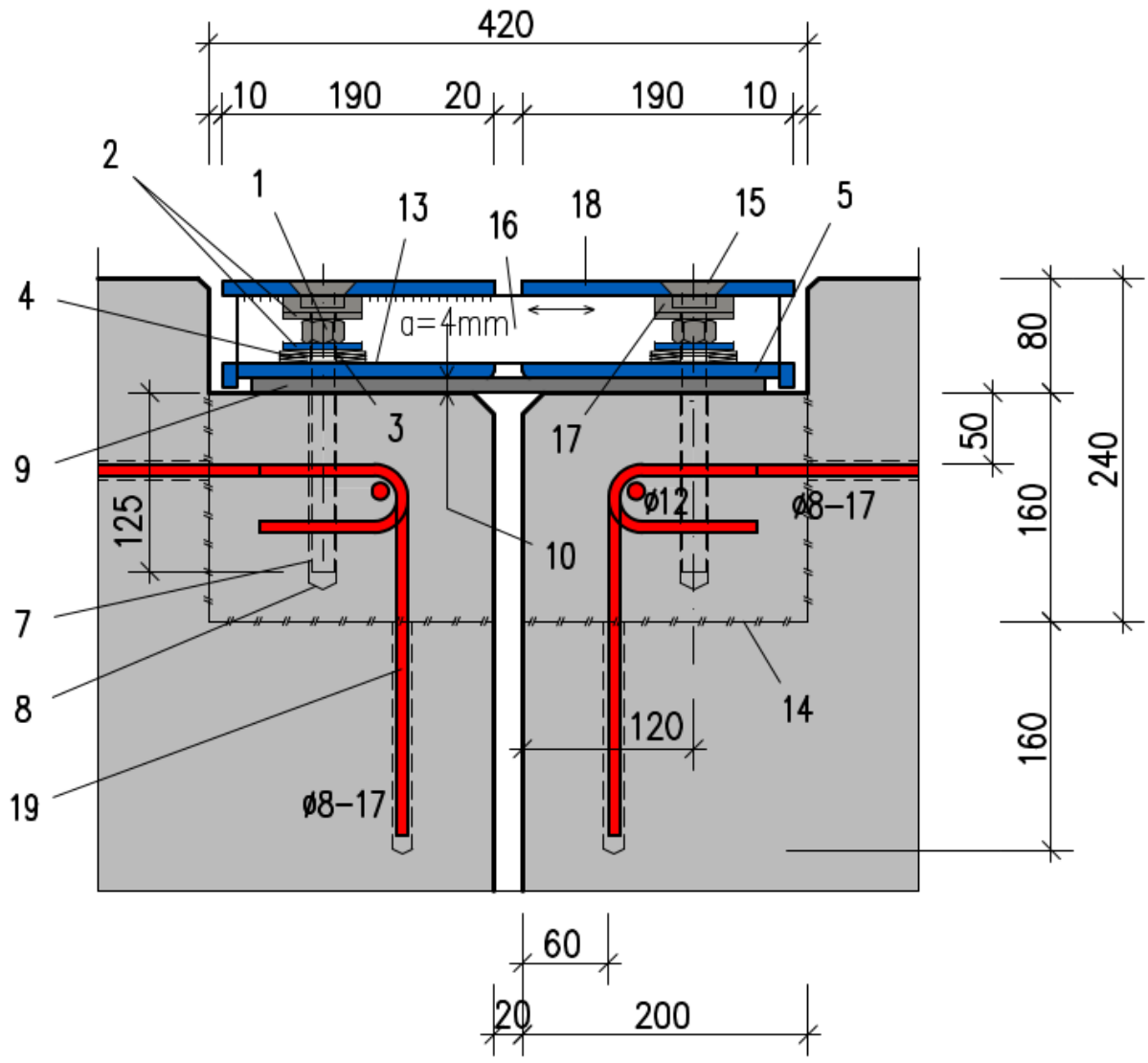
Legende, Mutter M16, Unterlegscheibe, Kunstoffbuchse, Tellerferdern, Flansch und Blech, Dübelüberstand bei Konstruktion mit Abdeckung

Legend, M16 nut, washer, plastic bushing, disc springs, flange and sheet metal, dowel projection for construction with cover = 75mm (without =

=75mm (ohne=55mm), Ankerstange, Ankerbohrung, Sthlseilbewehrtes Klemm-Fugenband (SBK), Wasserquellfähige Dichtmasse, Quellvlies, Injektionsmörtel, 1 :: dicker Dichtstreifen aus TPE oder Kunstofffolie

55mm), anchor rod, anchor borehole, steel cable reinforced clamping waterstop, water-swellable sealant, swelling fleece, injection mortar, 1 :: thick sealing tape made of TPE or plastic film

Figure 2: Steel cable reinforced clamping waterstop, detail of clamp construction (dimensions in mm)



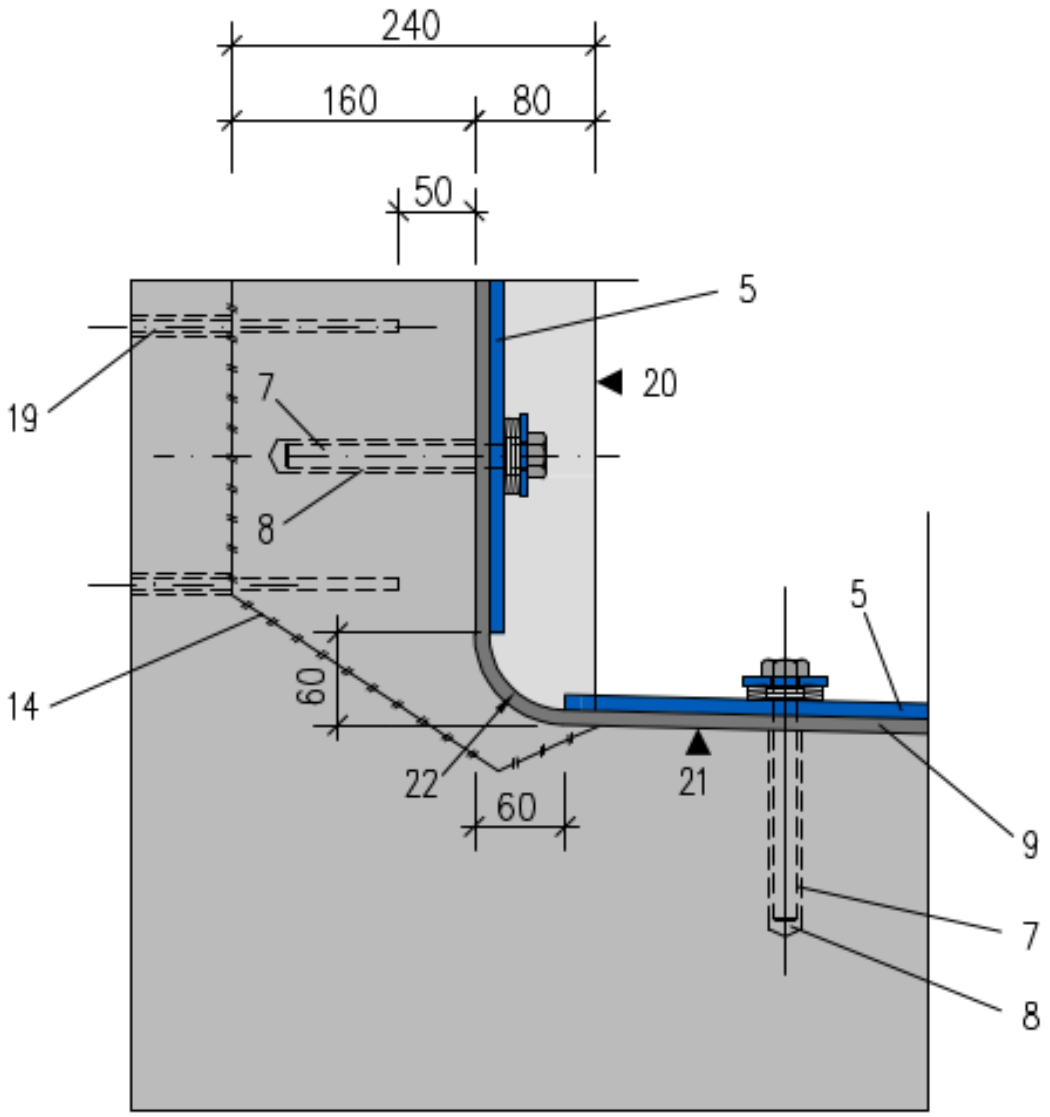
Legend

1 M16 nut
2 Washer
3 Plastic bushing
4 Disc springs
5 Flange 180x 10x ≤1000 and sheet metal 16x10x ≤1000
7 Anchor rod
8 Anchor borehole
9 Steel cable reinforced clamping waterstop with underlying swelling fleece
10 Water-swellable sealant
13 Sealing tape
14 Removal using high pressure jet washer
15 Conical nut, custom-made
16 Reinforcing plate
17 Spacer, custom-made
18 Cover plate
19 Reinforcement

Legende, Mutter M16, Unterlegscheibe, Kunstoffbuchse, Tellefedern, Flanch un Blech, Ankerstange, Ankerbohrung, Stahlseilbewehrtes Klemm-Fugenband (SDK) mit daruntrliegendem Quellvlies, Wasserquellfähige Dichtmasse, Dichtband, HDW-Abtrag, Kegelmutter, Sonderanfertigung, Verstärkungsblech, Distanzscheibe, Sonderanfertigung, Abdeckblech, Bewehrung

Legend, M16 nut, washer, plastic bushing, disc springs, flange and sheet metal, anchor rod, anchor borehole, steel cable reinforced clamping waterstop with underlying swelling fleece, water-swellable sealant, sealing tape, removal using high pressure jet washer, conical nut, custom-made, reinforcement plate, spacer, custom-made, cover plate, reinforcement

Figure 3: Steel cable-reinforced clamping waterstop, detail of chamber wall with cover for impact protection (dimensions in mm)



Legend

5	Loose flange
7	Anchor rod
8	Anchor borehole
9	Steel cable reinforced clamping waterstop
14	Removal using high pressure jet washer
19	Reinforcement
20	Inner edge of chamber wall
21	Omega clamping base
22	Radius = 50 mm

Legende, Losflansch, Ankerstange, Ankerbohrung, Stahlseilbewehrtes Klemm-Fugenband (SBK), HDW-Abtrag, Bewehrung, Innenkante Kammerwand, OK Sohle, Radius=50mm

Legend, loose flange, anchor rod, anchor borehole, steel cable reinforced clamping waterstop, removal using high pressure jet washer, reinforcement, inner edge of chamber wall, upper edge of base, radius=50mm

Figure 4: *Steel cable-reinforced clamping waterstop, detail of corner formation of chamber wall/base (change of direction in the sealing layer) (dimensions in mm)*