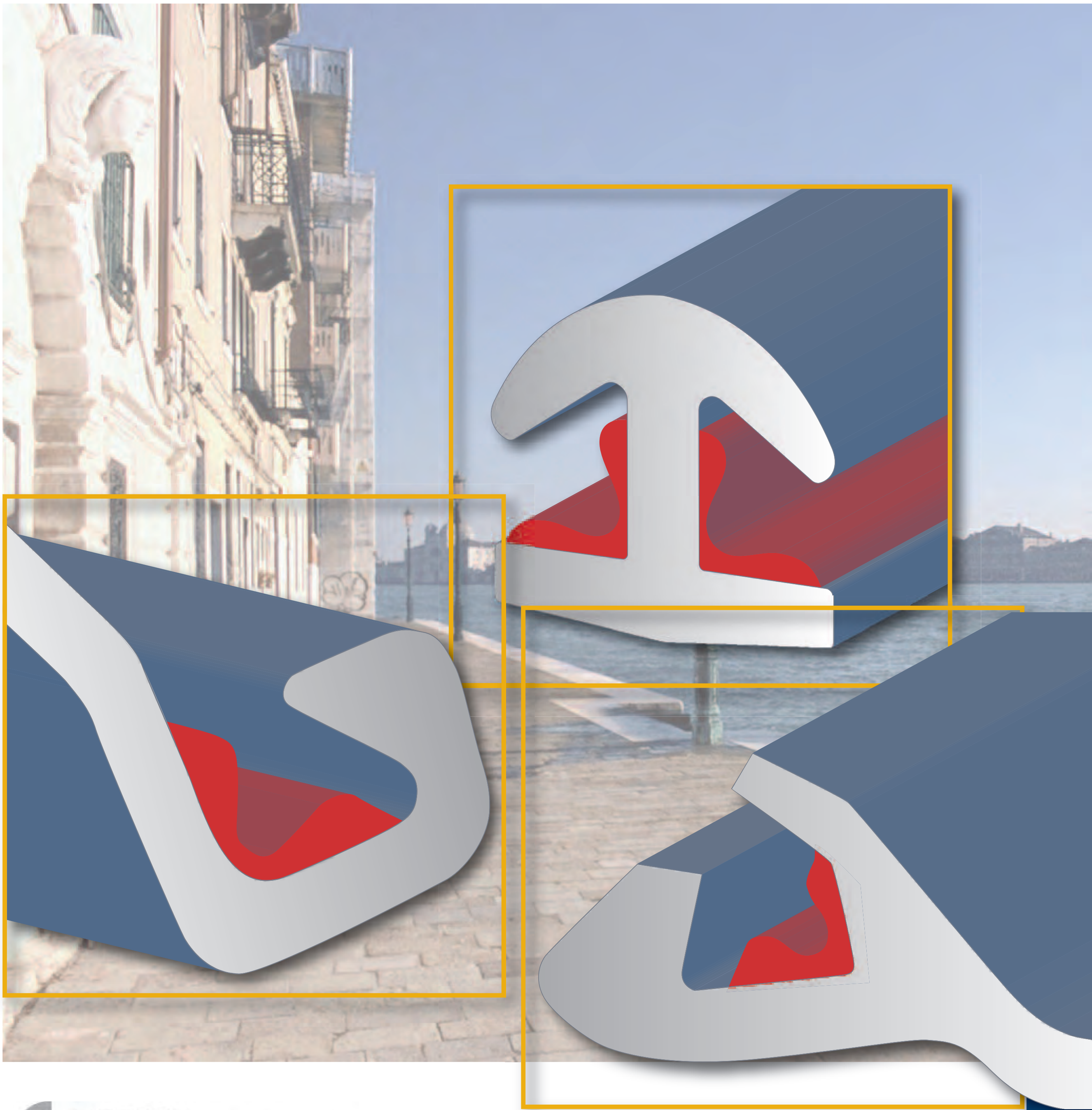
HOESCH steel sheet piling.
Interlock sealing systems.



HOESCH SPUNDWAND UND PROFIL
A Member of the Salzgitter Group

PEINER TRÄGER
A Member of the Salzgitter Group

A company of ThyssenKrupp Services

ThyssenKrupp GfT Bautechnik

ThyssenKrupp

CONTENT

Sheet piling for sealing walls.

For many years, steel sheet piling has been used successfully as a structural element on building sites and in hydraulic engineering and port construction due to its excellent static and sealing properties.

The use of steel sheet piling as a sealing element has gained popularity since the early 1980's, particularly for landfills and for the remediation of contaminated sites. One of the many advantages of sheet piling is that it is impermeable to hazardous materials, so the possibility of seepage is limited to the interlock zone. Sheet piling can be installed in a variety of sealing wall systems, either as a supplement to other elements or as the sealing component itself.

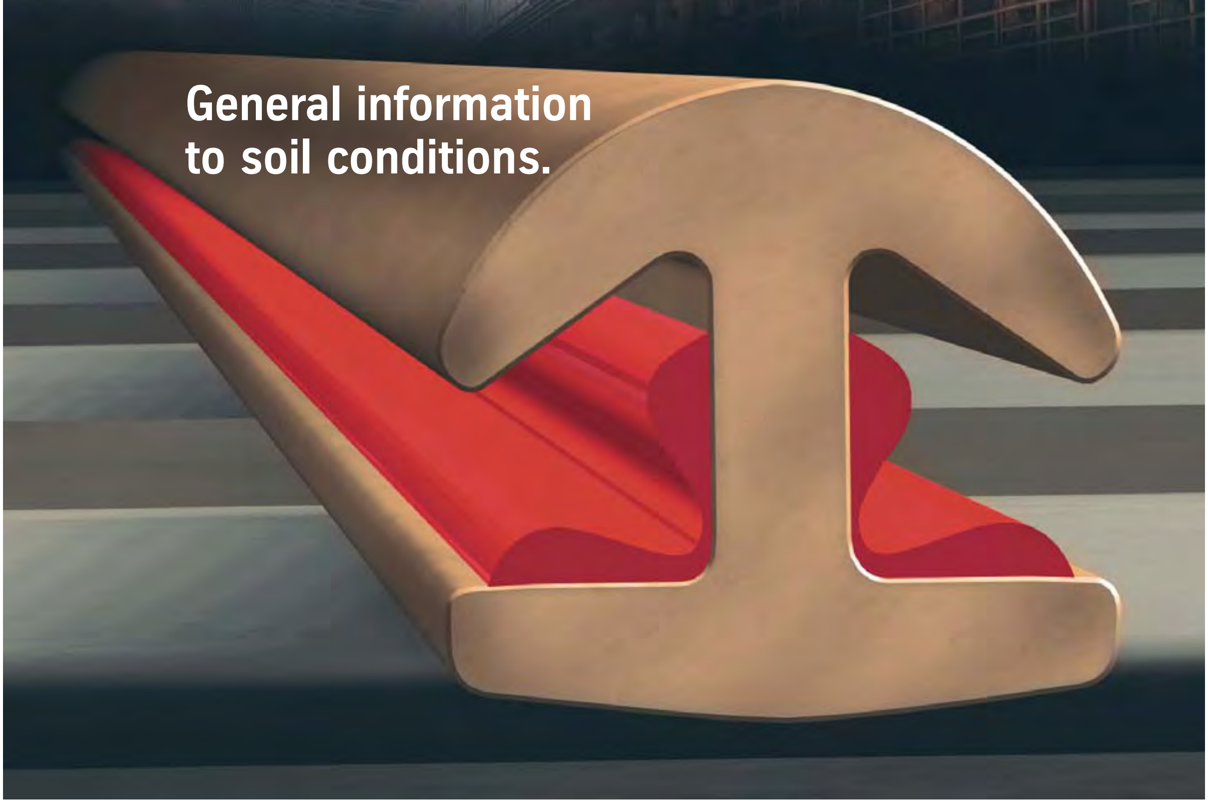
The production process is governed by a quality management system which is certified to ISO 9001 from the very first stage to the finished product, including fitted interlock sealing systems or interlock fillers. As a certain amount of clearance is needed to allow steel piles to be threaded, the interlocks on these piles are not fully watertight, although those on LARSSEN and HOESCH sections are labyrinthine making seepage routes relatively lengthy. This also facilitates the progressive "self-sealing" process which takes place over time under the right conditions, above all the existence of fine particles in the ground which work their way into the interlocks and eventually block them.

If the ground in question has a very low fine-particle content,or the job at hand places special requirements on the sealing properties of the sheet piling, artificial interlock sealing is the ideal solution.

Depending on the degree of sealing required, interlock joints can either be welded together or closed by a variety of sealing systems. The HOESCH interlock sealing system (EP 0695832) is particularly recommended for permanent structures, e. g. stormwater barriers or the enclosure of contaminated sites, which demand not only reliable sealing but also resistance to aggressive substances.

Bitumen-based interlock fillers have proved highly successful on temporary building projects for which the steel piles are to be reused.

General information to soil conditions.



PEINE locking bar
with the HOESCH interlock sealing system

Ground water permeability depends among other things on the particle sizes involved, their structure and strata density. Permeability diminishes the higher the proportion of fines in the ground. The coefficient of permeability "k" indicates the water permeability of various ground types. The k value is the calculated form of a physical speed at which water at a temperature of 10°C and a hydraulic gradient of i = 1 flows into a ground sample fitted in a test unit. The calculation of k values for various ground types is governed by DIN EN standard 18130. Darcy's law is used as a basis for theoretical observations.

For structural purposes, ground types are divided into five permeability classifications. Several special civil engineering methods are available to reduce ground permeability for structural purposes on a temporary or permanent basis.

All methods can generally be divided into the following categories or combinations of same:

A Displacement of ground and installation of a sealing material

B Excavation of ground and installation of a sealing material

C Reduction of ground permeability

When selecting the method to be applied, a general decision must be made as to whether only a sealing effect is required or whether an additional load bearing function in horizontal/vertical axis is desired.

The choice of sealing wall is based not only on static and installation requirements but also on permissible permeation rates, which must be described in detail as laid down for steel sheet piling in the German standard VOB part C – general technical contract conditions for construction work (ATV) – pile driving – DIN 18304, para. 0.2.10 or DIN EN 12063, para. 11.4.

LARSSEN section
with the HOESCH interlock sealing system

LARSSEN interlock
with the HOESCH interlock sealing system

Permeability classifications of soils:

Ground type	k [m/s]	Classification
1) clay; loam	$< 10^{-8}$	very slightly permeable
2) silt; sand, loamy, silty	$10^{-8} – 10^{-6}$	slightly permeable
3) fine sand; medium sand	$10^{-6} – 10^{-4}$	permeable
4) coarse sand; medium gravel; fine gravel	$10^{-4} – 10^{-2}$	highly permeable
5) coarse gravel	$> 10^{-2}$	very highly permeable

The tender specification should indicate permeability requirements in terms of maximum permissible water quantities per unit of time and square metre water-moistened of wall area at a given water pressure; simply indicating that the wall should be watertight or virtually watertight is not sufficient. Details of the permeability/tightness of sheet-pile walls are provided on pages 10 to 13 of this brochure.

HOESCH interlock sealing system (DBP 44 27561; EP 0 695 832).

The HOESCH interlock sealing system is factory-fitted in the sheet piling interlocks. It comprises a machine-profiled seal in the threading interlock and an injected seal adapted to the interlock slot in the pre-fabricated interlock. Treatment with an appropriate primer ensures excellent adhesion and prevents the formation of rust underneath the seal.

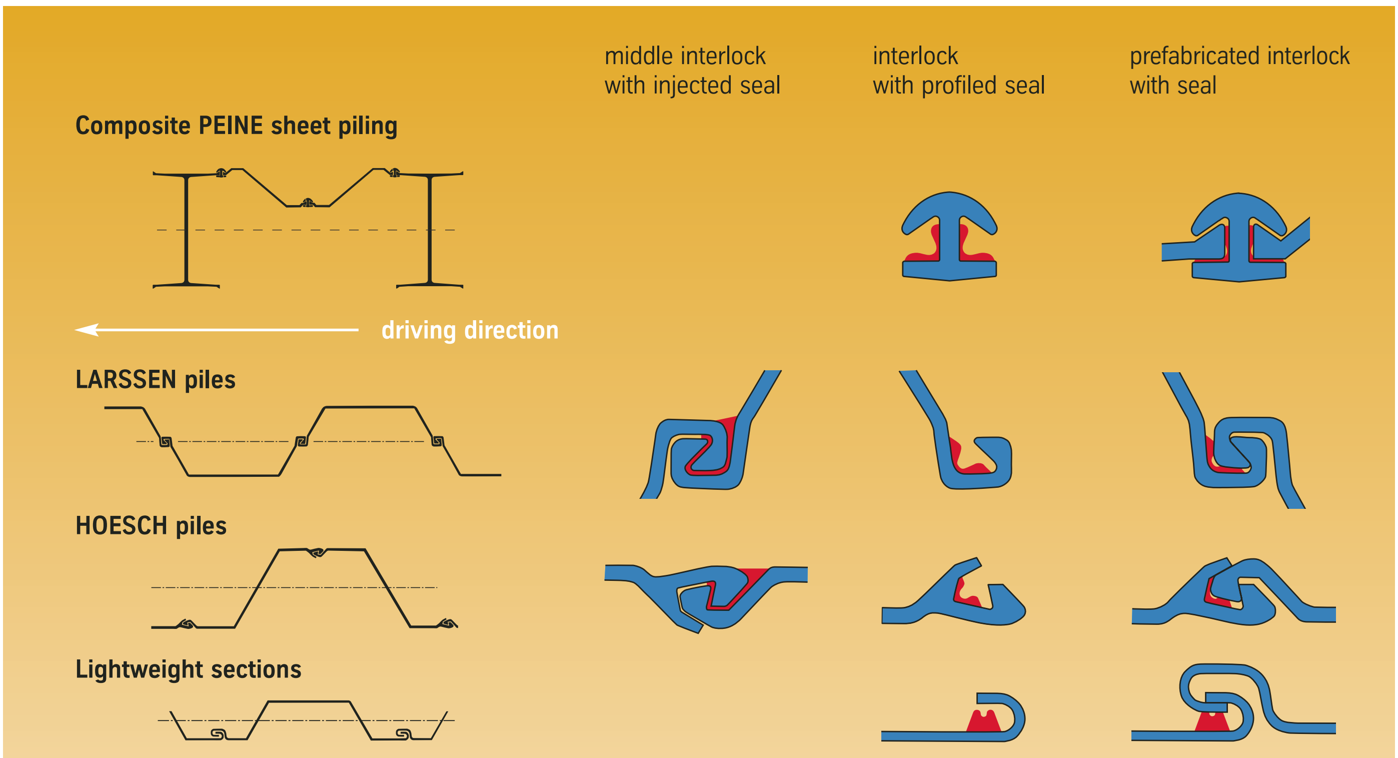
The seal in the threading interlock is such that restoring forces in the sealing material are activated during pile driving which then seal off the interlock slot in the required zones (compression sealing). The provision of two sealing lips in the interlock makes the sealing system doubly secure. The driving interlock, into which the next pile with profiled seal is threaded, is bevelled to facilitate the threading process. When continuously driving sealed piles it is therefore important for the driving direction to be set out in a driving plan prior to construction and for this plan to be observed on site.

Material properties
The seal is made of a permanently elastic polyurethane material which is resistant to ageing, weathering, water, seawater, normal effluent, mineral oils and a variety of acids and caustic solutions. Hazardous materials differ greatly in composition and concentration from one landfill/contaminated site to another. For this reason, HSP Hoesch Spundwand und Profil GmbH has tests performed on the resistance of its seals for differing applications and the enviromental compatibility of its sealing materials is documented in a number of test certificates.

Product data

Base	polyurethane/epoxy resin
Solvents	none
Colour	red/brown
Elongation at fracture	approx. 100 %
Flash point	100°C

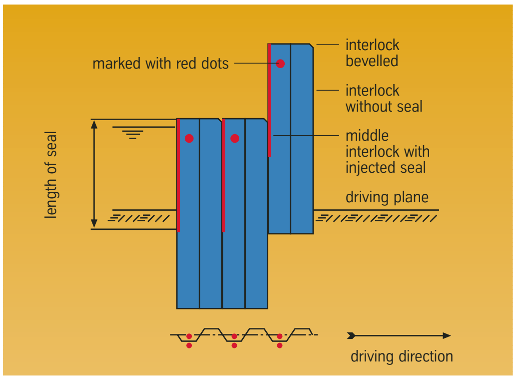
Piledriving instructions
Selecting the driving process:
For preference, piles featuring the HOESCH interlock sealing system should be installed by percussive driving. If circumstances allow, it is also possible to use the vibration driving process.
For this, the ground must have good vibrating properties; driving progress must be continuous and no slower than 10 seconds per metre. If it takes longer than this to install the pile, or progress is interrupted, it is better to continue using percussive equipment.
Cooling the threading interlock seal with water during vibration has proved advantageous.

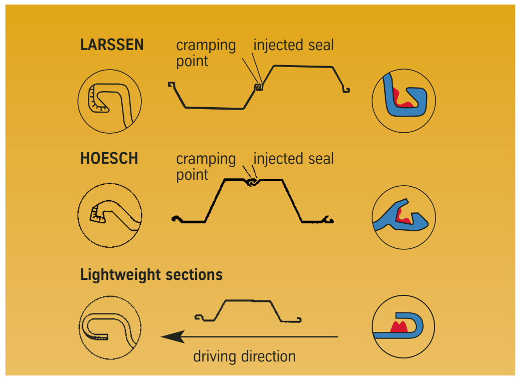


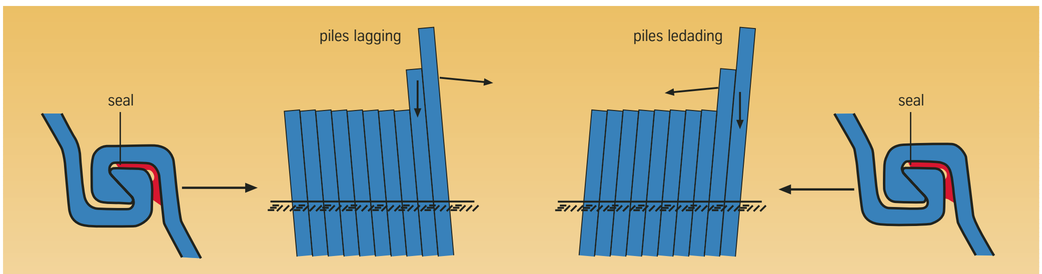
HOESCH interlock sealing system (DBP 44 27561; EP 0 695 832).

The suitability of interlock sealing for pressing depends on the process selected. It is advisable to consult ThyssenKrupp GfT Bautechnik on this before-hand. During the winter it is important that the pile temperature does not drop below -5°C since the formation of ice crystals in the threading interlocks can cause damage to the profiled seal. The sealed interlocks should be kept free of snow and ice.

Assainissement Gulbener Straße, Cottbus







Assainissement site pollué Brohl-Lützing

Seal lubrication
Regardless of the method used, HSP GM lubricant must be brushed evenly along the full length of the profiled interlock seal (approx. 100 g per metre) prior to driving. HSP GM is biodegradable and can thus be used in protected drinking water zones. The lubricant is water resistant, remains stable at low temperatures down to -5°C and displays good adhesive properties. Appropriate quantities of lubricant are included in the scope of supply.

Pile guiding
When driving sealed piles, special attention must be paid to guiding so as to avoid leading, lagging or inclining. Corrective measures must not cause any contraction of the interlock slot containing the profiled seal. For this you find comments in DIN EN 12063 and in EAU, E 118.

Driving direction
When using sealed piles, the driving direction must be stipulated prior to installation. When positioning the double piles onsite, care must be taken to ensure

- on LARSSEN piles that the free interlock is driven first and the interlock with the seal is threaded;
- on HOESCH piles that the finger is driven first and the sealed socket is threaded;
- on lightweight and sheet sections that the free interlock is driven first and the interlock with the seal is threaded.

For threading, the pile must therefore be turned in such a way that the unsealed interlock is pointing in the driving direction. The position of the seal is indicated by a coloured dot on the pile head. Normally sheet piles should be driven continuously, but staggered installation is also a possibility. The result of the suitable method should take place on the basis of the whole installation conditions.

Interlock fillers.

Filling the site threading inter-locks with bituminous materials prior to driving greatly enhances the water impermeability of the interlocks.

Sheet piling interlocks can be provided with bitumen-based fillers in the factory or on the site. Interlock fillers work on the replacement principle, that means surplus material will be pressed out of the interlock by the following lock. Depending on the temperature, it is possible that a higher driving energy is needed. Differing materials are used depending on the pile driving process.

SIRO 88 is a hot bitumen sealant suitable for vibration driving. For percussion driving, a bituminous putty is recommended.

When injected in the factory, both systems – SIRO 88 and the putty – consist of a pasty filler in the driving interlock and an injected compound in the prefabricated middle interlock.

The materials adhere well to the steel surface, eliminating the need to pretreat the interlocks with primers. Certificates have been obtained testifying the environmental compatibility of these fillers.

SIRO 88
Material properties
SIRO 88 is a bitumen/elastomer hot sealing compound. After application and cooling, this material may be anything from soft to tough (depending on the ambient temperature) and displays excellent adhesion with the steel surface. An investigation by the Gelsenkirchen Hygiene Institute has found that SIRO 88 can also be used in protected drinking water zones without reservation.

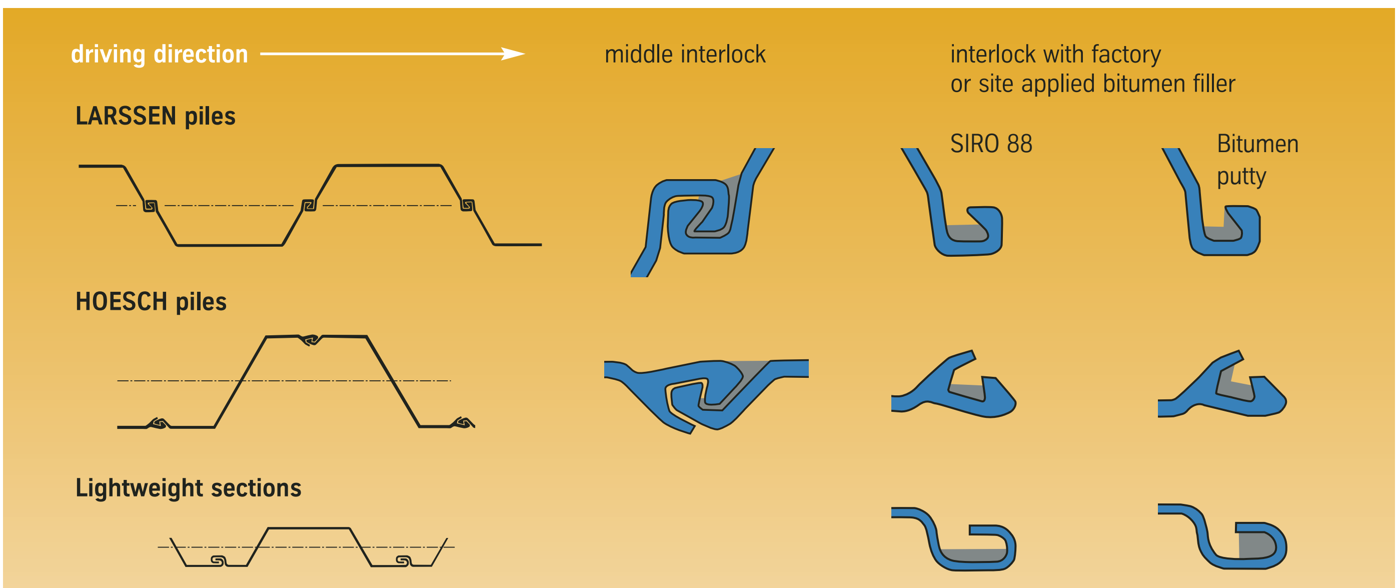
Product data

Base	bitumen
Colour	black
Pouring temperature	max. 180°C
Melting temperature	max. 200°C
Flash point	250°C
Water solubility	none

Bitumen putty
Material properties
The sealant used by HSP is a synthetic-resin modified single-component plastic bitumen putty which can be used to fill and seal interlocks on steel sheet piling. This bitumen putty displays good adhesion in the interlock slot and is able to withstand the forces of acceleration arising during the driving process. Its plastic properties remain even at low temperatures and the material can be used on site at temperatures down to -20°C. An investigation by the Gelsenkirchen Hygiene Institute has found that, as lubricant and sealant for sheet piling interlocks, this bitumen putty can be used without reservation in protected drinking water zones.

Product data

Base	bitumen
Colour	black
Consistency	pasty
Density	approx. 1.0 kg/dm³
Application	putty knife jointing iron
Flash point	approx. 36°C
Temperature resistance	up to 90°C
Water solubility	none



On site applications.

Melting the SIRO 88 sealing compound
Unwrap the block of SIRO 88 and heat it in a double-walled, indirectly-heated receptacle with thermostat control. The melted sealing compound must be stirred constantly to prevent overheating. It is advisable only to melt the quantity required for that day, since repeated melting changes the properties of the compound.

Pouring temperature:
approx. 180 °C
Melting temperature:
approx. 200 °C

If outside temperatures are below 5°C, the enhancing agent SIRO 88 P should be added to the SIRO 88 compound. 3 kg of SIRO 88 P should be used for each block of SIRO 88, mixing with a mechanical stirrer until a homogenous compound has been formed. Minimum stirring time: 3 minutes.

The interlocks and interlock joints must be dry, clean and free of oil and grease. Any contamination must be removed with a rotary wire brush; wet pile interlocks must be flame dried. Remove dust using condensate-free compressed air immediately prior to pouring.

Piles must be horizontal during pouring to ensure an even filling height, as shown on the adjacent drawing. At the first sign of rain, stop pouring. Piles are to be transported/ stored with the filled interlock opening facing upwards. If the piles are left in the sun for any period of time, they should be covered to prevent them from heating up.

Consumption
Approx. 250 to 450 g SIRO 88 per metre of interlock.

Packaging
SIRO 88 is supplied in 22 kg drums. SIRO 88 P is supplied in 30 kg drums.

Applying the bitumen putty
Interlocks and joints must be dry, clean and free of oil and grease. Any contamination is to be removed by mechanical brushing; wet pile interlocks must be flame dried. Remove dust using condensate-free compressed air immediately prior to filling.

The bitumen putty is filled into the interlock slot using an appropriate tool in accordance with the reference drawing. Piles are to be transported/ stored with the injected interlock opening facing upwards.

Consumption
Approx. 400 to 500 g of bitumen putty per metre of interlock.

Packaging
The bitumen putty is supplied in 30 kg drums.

Driving instructions
When using piles with interlock fillers, the driving direction must be stipulated prior to installation. Sheet piles with SIRO 88 filler should be vibrated into position for preference, whereas percussion driving is the better method for piles with bitumen putty. When positioning the double piles on site, care must be taken to ensure:

- on LARSSEN piles that the filled interlock is driven first and the free interlock is threaded;
- on HOESCH piles – contrary to normal practice – that the filled socket is driven first and the finger is threaded;
- on lightweight and panel sections that the filled interlock is driven first and the free interlock is threaded.

During threading, the pile must therefore be turned, so that the filled interlock is pointing in the direction of driving. On factory-filled sheet piles, the position of the filler is marked by a coloured bar on the pile head. It is important to ensure that piles are in vertical position and correctly aligned for installation.

During vibration driving, frictional heat in the threading interlock may cause the sealing compound to run out of the visible zone of the interlock or even burn. The following counter-measures are recommended:

- cool the interlocks with water
- use a more powerful vibrating driver.

Other sealing processes

For interlock joints which require sealing after the sheet piling has been installed, a number of processes are available. If sealing requirements are modest, it is possible to seal joints after installation with e. g. wooden wedges (swelling effect) or with rubber or plastic cords. However, if the interlocks need to be absolutely watertight, welding is the only answer. In general, this only affects the threading interlocks, since prefabricated interlocks can be welded tight before installation. Direct welding of the joint is only possible if the joint in question is clean and dry. Weld seams must be made on the side of the sheet piling facing the base of the structure to be built. If water is to run along the joints, they can be covered with a flat or sectional steel element which is fillet welded to the sheet piling. Further details on welding sheet piles can be found in [1]. [2, 3] provide details of how sheet piles can be driven into small sealing piles and how they can be installed in suspension-supported sealing walls.

[1] Spundwandhandbuch Berechnung, (2007)

[2] Andreas Wieners, "Die Stahlspundwand als Dichtwand in der Altlastensanierung" aus K. J. Thomé-Kozmiensky, Abdichtung und Ertüchtigung von Altablagerungen (1993)

[3] Andreas Wieners, "Praktische Erfahrungen bei der Sicherung von Altlasten mit Stahlspundwänden" aus Jessberger (Hrsg.), Sicherung von Altlasten (1993)

Positioning the piles

Due to the increased interlock friction associated with sealed sheet piles, it cannot be assumed that the weight of the pile itself will be enough to sink it to the required depth. For this reason, suitable driving equipment must be kept on site to drive the piles further into the ground if necessary. To this end, HSP can supply a special starter weight, use of which requires a carrier with free fall equipment.

Effects of high temperatures

Welding work near seals or fillers will have an adverse localised effect on these sealing materials. If subsequent welding cannot be avoided, resealing will be necessary.

Flame cutting

If sheet piles with the HOESCH interlock sealing system have to be shortened or straightened on site using flame cutting apparatus, the interlock of the driven pile must be bevelled by grinding before attempting to install the next pile. If the appropriate interlock is not treated in this way, the seal may suffer damage during subsequent threading. If piles with filled interlocks have to be shortened or straightened on site using flame cutting apparatus, great care is required since the bituminous sealants are flammable and may require water-cooling. Appropriate extinguishers should be kept on site.

Coating

Coating is no problem when using the HOESCH interlock sealing system. Factory priming and on-site end coating is an ideal combination as it gets round the problem of damage in transit or during handling. However, full factory coating can also be provided. In order to avoid rust streaking on the coated piles, any interlock gaps should be filled on site. When using piles with bituminous interlock fillers, coating is not recommended, since any filling material which is pressed out of the interlock during installation would contaminate the coated sheet pile and subsequent cleaning is both time-consuming and expensive.

Hot dip galvanising

Hot dip galvanised steel sheet piles in conjunction with the HOESCH interlock sealing system can also be used without any problems. As with coated piles, it is recommended that hot dip galvanised piles should not be filled with bituminous materials for the reasons stated above.

Tightness

The coefficient of permeability k is frequently used to describe the tightness of a sealing wall, i. e. tightness is defined in terms of permeability. However, the actual discharge rate Q to be expected at a specified water pressure is more meaningful. Sheet piling is such that any possible material leakage, be it through convection or diffusion, is restricted to the interlock zones, since the rest of the wall is impermeable. It is difficult to determine exactly how the interlock may be breached, but it is highly unlikely that porosity will be a factor, so Darcy's law cannot be applied to the localised seepage through sheet piling joints. Therefore the only way of comparing the permeability of mineral sealing walls and sheet piling interlocks is via the actual amount of seepage Q. "Interlock seepage resistance" values have been calculated for the various interlock types on the basis of DIN EN 12063. The resultant value ρ can be used both to calculate the quantity Q of seepage through an interlock and to make a comparison with a given k value for the calculation to DIN 12063. Always the integration of the sheet pile in a water tight soil layer is basically to avoid errors.

Selection criteria.

The adjacent calculation models have beend drawn up on the basis of DIN EN 12063:

Seepage resistance ρ

$$\rho = \frac{q(z) \times \gamma}{\Delta p(z)} \quad [m/s]$$

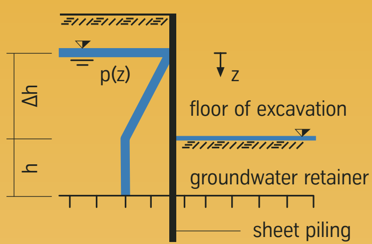
where:
q (z) = discharge rate over time related to interlock length [$m^3/m \times s$]
γ = specific gravity of fluid [kN/m^3]
$\Delta p(z)$ = water pressure [kN/m^2]

Seepage rate Q

The seepage rate Q through an interlock can be calculated as follows:

$$Q = \int_0^{\Delta h+h} q(z) \times dz = (\rho/\gamma) \times \int_0^{\Delta h+h} \Delta p(z) \times dz$$

$$Q = \rho \times \Delta h \times (0{,}5 \times \Delta h + h) \; [m^3/s \times lock]$$



To allow tightness comparison with diaphragm walls of grouted curtain walls, it is possible to use the water permeability coefficient k in accordance with DIN EN 18130 part 1 for soils (porous media).

$$k = \frac{Q}{i \times A} \quad [m/s] \quad \longrightarrow \quad Q = \frac{k \times \Delta p(z)}{\gamma \times d} \times A [m^3/s]$$

where:
Q = measured water flow rate [m^3/s]
i = hydraulic gradient [-]
A = cross sectional area, wall area [m^2]

By observing these basic correlations and taking into account the decisive quantity of sheet piling interlocks per m² of wall area, the following correlation results with a constant seapage rate Q:

$$\frac{k \times \Delta p(z)}{\gamma \times d} = \frac{\rho \times \Delta p(z)}{\gamma \times b}$$

$$\longrightarrow \frac{k}{d} = \frac{\rho}{b}$$

where:
d = thickness of diaphragm wall [m]
b = pile width or element width [m]

Selection criteria for suitable interlock sealing

Example:
A vertical sealing wall with a depth of 10.5 m is to be set up to enclose a contami-nated site. The ground has been contaminated with the following: chlorinated dioxins and furans, chlorobenzenes, chlorophenols, oils, mineral oils, polycyclic aromatics, aliphatic and aromatic solvents.

The wall selected must be resistant to all these hazardous substances. The requirement placed on permeability is $k \leq 1.0 \times 10^{-9}$ m/s with a notional thickness of d = 60 cm.

In view of the quality requirements, only factory sealed sheet piles should be permitted. The required section modulus is $W_y \geq 1100$ cm³/m. The suitable sealing system is selected on the basis of the following criteria:

Tightness

The requirement for interlock seepage resistance ρ is ρ req. $\leq$ k x b/d

Column 5 of the table on page 13 shows that to achieve equivalence with a 60 cm thick membrane wall with $k \leq 1.0 \text{-} x\ 10^{-9}$ [m/s] the minimum requirement is for single piles with the HOESCH interlock sealing system in the threading interlock, the decisive element width being ≥ - 0.50 m. On static grounds, the section modulus required for this example must be ≥ 1100-cm³/m.

The following sections can thus be selected:

Section --	W_y cm³/m	Decisive element width m	comparable k with a 60 cm wide membrane wall m/s	Tightness requirements met	Resistance requirements met
E HOESCH 1205	1140	0,575	$1{,}9 \times 10^{-10}$	yes	yes
E LARSSEN 605 K	2030	0,60	$1{,}8 \times 10^{-10}$	yes	yes
D LARSSEN 603	1200	1,20	$9{,}0 \times 10^{-11}$	yes	yes
D LARSSEN 703	1210	1,40	$7{,}7 \times 10^{-11}$	yes	yes

The LARSSEN 703 section is selected on economic grounds. Tightness thus equates to that of a 60 cm wide membrane wall with a k value of 7.7×10^{-11} m/s or, if an 80 cm thick membrane wall is selected, a k value of 1.0×10^{-10} m/s.

In comparison, however, a narrow wall – due to its reduced thickness – would require a k value of 1.0×10^{-11} m/s to match the tightness of the sheet piling.

Resistance

When selecting a suitable interlock sealing system to enclose a contaminated site, it is important not only to satisfy demands for tightness but also for resistance to the contaminants involved.

Bituminous sealing materials are not resistant to the hazardous substances indicated (aliphatic and aromatic solvents, oils, mineral oils etc.).

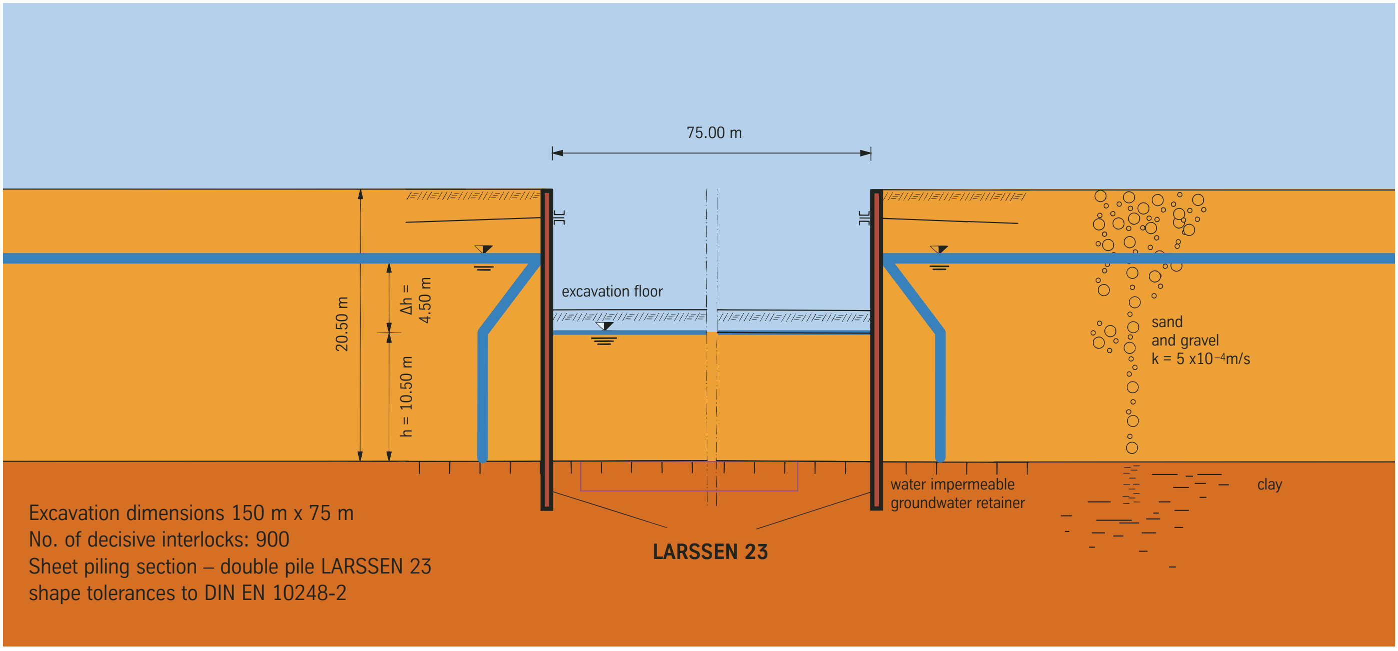
Long-term exposure tests have shown that the HOESCH interlock sealing system is resistant to the contaminants involved in this case.

Comparable k values of other sealing walls

In order to match the tightness of a sheet-pile wall, a membrane wall or narrow wall would – depending on thickness – have to provide the following k values.

Sealing system	Section	Decisive element width	ρ	Required k-value for a membrane wall		narrow wall
		b [m]	[m/s]	d = 0.60 m	d = 0.80 m	d = 0.08 m
Single piles with SIRO 88 filler in each interlock	LARSSEN 23-25	0.50	6.0×10^{-8}	7.2×10^{-8}	9.6×10^{-8}	9.6×10^{-9}
	HOESCH 1105-2605	0.575		6.3×10^{-8}	8.3×10^{-8}	8.3×10^{-9}
	LARSSEN 600-607n	0.60		6.0×10^{-8}	8.0×10^{-8}	8.0×10^{-9}
	HOESCH 1706-3806	0.675		5.3×10^{-8}	7.1×10^{-8}	7.1×10^{-9}
	LARSSEN 703-704	0.70		5.1×10^{-8}	6.9×10^{-8}	6.9×10^{-9}
	LARSSEN 755	0.75		4.8×10^{-8}	6.4×10^{-8}	6.4×10^{-9}
Double piles with SIRO 88 filler in the driving interlock and compound in the middle interlock	LARSSEN 23-25	1.00	6.0×10^{-8}	3.6×10^{-8}	4.8×10^{-8}	4.8×10^{-9}
	HOESCH 1105-2605	1.15		3.1×10^{-8}	4.2×10^{-8}	4.2×10^{-9}
	LARSSEN 600-607n	1.20		3.0×10^{-8}	4.0×10^{-8}	4.0×10^{-9}
	HOESCH 1706-3806	1.35		2.7×10^{-8}	3.6×10^{-8}	3.6×10^{-9}
	LARSSEN 703-704	1.40		2.6×10^{-8}	3.4×10^{-8}	3.4×10^{-9}
	LARSSEN 755	1.50		2.4×10^{-8}	3.2×10^{-8}	3.2×10^{-9}
Single piles with HOESCH interlock sealing system in each interlock	LARSSEN 23-25	0.50	1.8×10^{-10}	2.2×10^{-10}	2.9×10^{-10}	2.9×10^{-11}
	HOESCH 1105-2605	0.575		1.9×10^{-10}	2.5×10^{-10}	2.5×10^{-11}
	LARSSEN 600-607n	0.60		1.8×10^{-10}	2.4×10^{-10}	2.4×10^{-11}
	HOESCH 1706-3806	0.675		1.6×10^{-10}	2.1×10^{-10}	2.1×10^{-11}
	LARSSEN 703-704	0.70		1.5×10^{-10}	2.1×10^{-10}	2.1×10^{-11}
	LARSSEN 755	0.75		1.46×10^{-10}	1.9×10^{-10}	1.9×10^{-11}
Double piles with HOESCH interlock sealing system in each interlock	LARSSEN 23-25	1.00	1.8×10^{-10}	1.1×10^{-10}	1.4×10^{-10}	1.4×10^{-11}
	HOESCH 1105-2605	1.15		9.4×10^{-11}	1.3×10^{-10}	1.3×10^{-11}
	LARSSEN 600-607n	1.20		9.0×10^{-11}	1.2×10^{-10}	1.2×10^{-11}
	HOESCH 1706-3806	1.35		8.1×10^{-12}	1.1×10^{-10}	1.1×10^{-11}
	LARSSEN 703-704	1.40		7.7×10^{-11}	1.0×10^{-10}	1.0×10^{-11}
	LARSSEN 755	1.50		7.2×10^{-11}	9.6×10^{-11}	9.6×10^{-12}
Triple piles with HOESCH interlock sealing system in the threading interlock and injected sealant in the middle interlocks	LARSSEN 23-25	1.50	1.8×10^{-10}	7.2×10^{-11}	9.6×10^{-11}	9.6×10^{-12}
	LARSSEN 600-607n	1.80		6.0×10^{-11}	8.0×10^{-11}	8.0×10^{-12}
	LARSSEN 703-704	2.10		5.1×10^{-11}	6.9×10^{-11}	6.9×10^{-12}
	LARSSEN 755	2.25		4.8×10^{-11}	6.4×10^{-11}	6.4×10^{-12}

Water ingression into an excavation: comparison between interpile sheeting with groundwater lowering and steel piling with differing sealing systems.



System	ρ [m/s]	Decisive element width for double pile LARSSEN 23 [m]	No. of interlocks possible with restricted seepage	Ingression into excavation [l/s]	[%]	Reduction in water quantity to be pumped out [%]
Groundwater lowering with interpile sheeting				~ 115	100	÷
Sheet piling with interlock sealing*	8×10^{-4} x k ground/b	0.5	900	~ 41	36	64
Sheet piling with site-applied interlock filler SIRO 88 in each interlock	6×10^{-8}	0.5	900	~ 3.1	3	97
Sheet piling with factory applied interlock fillers SIRO 88 in the driving interlock and compound in the middle interlock	6×10^{-8}	1	450	~ 1.5	1.3	99
Sheet piling in the HOESCH interlock sealing system in the threading interlock and injected sealant in the middle interlock	1.8×10^{-10}	1	450	~ 0.005	0.004	10

* ρ is largely dependent on ground type and requires a wide particle curve with a sufficient of fines.
This is an approximation formula for the calculation of ρ in which the pile width b in [m] is to be inserted.

Applications.

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Fig. 1 CT 4, Bremerhaven
Fig. 2 Underground car park, Den Haag
Fig. 3 MOSE, Venice
Fig. 4 Excavation, Leipzig
Fig. 5 Landfill, Asslar
Fig. 6 Headworks for dam across Dhünn Valley, Müllenberg/Viersbach

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HOESCH interlock sealing system

- Structures with high sealing requirements and additional corrosion protection coating.
- Excavation in water, especially with varying water levels.
- Support walls, bridge abutments, underground garages and tunnels for which it is essential to prevent water from penetrating through the interlock joints.
- Soil-installed sealing walls (cofferdams, protective walls for tank farms).
- Enclosure of landfils and contaminated sites.

Bituminous interlock fillers

- Temporary structures, excavations in water, excavations in soil with low proportion of fines or unsuitable particle size curve.
- Securing waterway embankments in dam areas or where ground seepage must be avoided (water conservation area).

Productivity description interlock sealing.

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Specifying the most suitable sealing system
Despite preliminary examinations to determine the suitability of specific sealing materials, it is frequently the case that invitations to tender include only a generalised requirement for interlock-sealed steel piles. An ideal tender specification for the example quoted on page 12 could be worded as follows:

Item	Description of service required	Unit price	Total price
.....	Supply of steel piles	.....	.....
.....	Steel piles in accordance with DIN EN 10248 to be supplied free on site to drawing and project description in line with static, driving and structural requirements. The piles remain in the ground.	.....	.....
.....	Pile section: Z-shaped piles and single or double piles (e.g. HOESCH 1200), U-shaped piles as shear-resistant interlocked double piles (e.g. LARSSEN 703)	.....	.....
.....	Steel grade: S 240 GP (St Sp 37)	.....	.....
.....	Section modulus: ≥ 1100 cm^3/m	.....	.....
.....	Pile length: 10.5 metres	.....	.....
.....	Sealing: HOESCH interlock sealing system (or equivalent) along full pile length. Bituminous seals are not permitted. Equivalence is measured in terms of tightness and resistance. References required for remediation of contaminated sites.	.....	.....
.....	m^2	.....	.....

Fig. 7 Artificial drilling island Mittelplate, North Sea
Fig. 8 Flood protection, Cologne-Worringen
Fig. 9 Bridge over the River Main at Stockstadt

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