Operations manual

Wet spraying techniques using ERGELIT WW coating mortars

1st edition September 2020

HERMES TECHNOLOGIE

HERMES
TECHNOLOGIE

Index

Page

Page

1. Introduction

Spray mortar is a rapid setting material for stabilising and consolidating man-entry drainage pipes and sewage installations, and for renewing, renovating and providing corrosion protection, without the use of formwork. The quality of spray coating is dependant upon the correct combination of man, machinery and material – the mineral WW (Wastewater) coating mortar.
The nozzle operator must be a highly skilled and diligent worker, and must have complete confidence in the correct equipment and the selected spray mortar. The success of a spray mortar operation depends on the quality of these three elements working together.
In these times of increasing environmental awareness, and given today's dense living conditions, there is an ever greater need for watertight drainage systems, as existing drainage networks reach the end of their useful life. Factory-produced dry mortar is the basis of modern spray mortars. This type of construction work is outstanding from the economic point of view and has virtually no technical limitations in the area of man-entry pipes, providing solutions to a wide range of technical challenges.
Shotcrete, which was first used in 1914, has undergone constant development and improvement in recent decades. Modern spray mortars have been used in drain rehabilitation since 1981.
There are four different coating techniques using cement-based WW coating mortars:

- Manual coating
- Wet spraying
- Centrifugal spraying
- Injection

Coating by hand (see the “Hand Coating” operational manual) is used for areas of up to 50m^2. Wet spray coating is used for coating areas from 30m^2 and upwards.

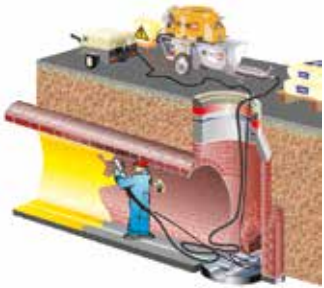
Nowadays a basic distinction is made between the two mortar spraying techniques:

» dry spraying
» wet spraying

Dry spraying machine

For drain and sewer renovation, the wet spray technique is now the established method. The most important demands that users make on spray mortar formulations focus on workability - their pumping and spraying characteristics:

» high early strength and early cured strength
» task-specific hardened mortar properties
» user-friendly processing times (long open time)
» spray mortar capacity to take water load quickly



Process overview: wet spraying

- good dense phase pumpability
- good sprayability (elasticity)
- minimal rebound

For the Asset owner, durability is key. Quality is regulated in DIN 19573. “Sprayed mortar concreting” describes how the process is carried out. Sprayed mortar and sprayed concrete are differentiated by their grain size.

Grain size for sprayed mortar is < 8 mm and usually <4mm.
Grain size for sprayed concrete is > 8 mm

Comparison of dry and wet mortar spraying		
Criteria	**Dry**	**Wet**
Dust formation	high	low
Rebound	high	low
Spray capacity	high	low
Equipment costs	low	small
Cross-sections	large	small
Pumping distances	large	small
Delivery volumes	large	small
Cleaning costs	low	high
Interruption of work	simple	difficult
Quality	varies	consistent
Distance from substrate	large	small
Coating thicknesses	thick	thin

Spray mortar is delivered in the conventional way from the mixing unit to the application equipment. The mortar is pumped to the point of application along self-contained, pressure resistant hoses and sprayed on to form a dense coating. A distinction is made between the following processes:

- dense phase technique for wet spray mortars
- lean phase technique for dry spray mortars

Wet spray nozzle for larger quantities

Wet spray nozzle for small to medium quantities

The spray mortar is first conveyed at high speed to the spray nozzle. The spray jet is formed at that point, the exact amount of air-pressure being provided by the dense phase system. The mortar mix is now ready and is propelled onto the substrate under high pressure, forming such a dense, solid coating that – depending on the ERGELIT® mortar selected – the mortar can be applied in any direction, even vertically overhead.

Wet spraying in a man-entry sewer

Wet spraying in a tank

Wet-spraying is a coating procedure using ERGELIT WW-coating mortars. It is used for the rehabilitation of domestic and industrial drainage installations and structures.

This procedure improves the functionality and stability of installations, shafts, fat and light liquids separators and sewers.

Such improvement is based on a complete or partial inspection of the original material of which the structures or installations are made. In the case of concrete or reinforced concrete constructions, this procedure can also be used as a concrete replacement system.

The procedure is a rehabilitation procedure as defined in DIN EN 752. In the section on rehabilitation in DIN EN 15885, wet spraying techniques are listed under “Lining using coating procedures“. The requirements for sprayed mortar are laid down by DIN 19573 taken together with DIN EN 1503-3. Injection procedures are described in DWA-M 143-8, as are the requirements for injection materials e.g. ERGELIT-KBi WW injection mortar. The damage symptoms (see DIN EN 13508-2) that typically affect wastewater structures and installations are leaks and chemical or biochemical impact or attack on the inner surfaces both below and above the water line, reacting with the wastewater structure’s cement-based and metal components and materials. See also DWA-M 168. This reaction results in these components and materials suffering corrosion and loss. Such damage can lead to a reduction in wall strength and hence to a reduction in a structure‘s load-bearing capacity.

2. Areas of application

Sprayed mortar must comply with DWA-M 143-7 and hence with DIN19573. Where there is lactic acid attack in dairies or attack by other organic acids such as in industrial situations, it is recommended to carry out a further examination of stability. It has proved to be practicable to suspend mortar prisms for 3 to 6 months in the wastewater. They should be checked on a monthly basis. If the mortar cannot resist the chemical stress, KeraLine tiles or ceramic inserts or HDPE dimpled sheets can be used as additional cladding. Compared with sulphuric acid, organic acids such as lactic

acid cause significantly heavier attacks for the same pH value. In such cases, HERMES Technologie's experts should be consulted. As a general rule one should be guided by DWA M 168, but DIN 19573 is also a source of information.

3. Possible types of damage

3.1. Infiltration

Undichtigkeiten

This sometimes stems from the construction of the shafts or pipes. Bricks may often not have been properly pointed to begin with, or waterproof mortars to the correct standard may not have been used. A 'standard' cement mortar as per DIN 1053 or DIN EN 998 is not water pressure tight, but is intended for civil engineering use. Brick-built shafts or sewers are constructed using process-controlled, factory-made dry mortars that have to conform to DIN 19573. Exclusively WW masonry mortar must be used. That is the only way the eventual network operator can have full confidence in the watertightness of the structure. High traffic loads and settlement may later lead to cracks in the masonry. Leaks are rarely caused by material corrosion. In the case of shafts made of pre-cast components, leaks are usually limited to the joints. Incorrect installation is often to blame.

Shaft drilling scheme.

Drilling scheme in sewer

Remedial investigations show up more and more shaft rings with inadequate pointing. Leaks that have continued for decades can also lead to disturbance of the old pipe or the subsoil with consequential

deterioration of the bedding. In such cases, backfilling the cavities and restoring the bedding with ERGELIT-KBi have proved successful.

3.2. Corrosion

Once an inspection shaft starts to fail, this is bound to lead to leaks. Many shafts and sewers start to show signs of ageing in the form of corrosion. Most are over 50-100 years old, so they will usually need to be rehabilitated. A large proportion have suffered localised corrosion in the last 5-10 years, even though the shafts are quite old and had shown no previous signs of corrosion. The causes are mostly down to a change in the way the wastewater structure is being used. Even the present-day trend to use less drinking water may contribute to new operational stresses, for example increased sedimentation caused by a decrease in flow velocity as a result of a reduction in water volume. Where there are changes of use, care must be taken to ensure that no subsequent operating conditions arise that could lead to increased BSC (biogenic sulphuric acid corrosion). There is a brief account of these interconnections in DWA M 168.

Corrosion

It should be noted that BSC arises when there are long wastewater flow times for a period greater than 12 hours, and high wastewater temperatures (> 20ºC) as well as poor ventilation, i.e. little exchange of air, in the wastewater network. In such cases, sprayed mortars or shotcrete must conform with exposure class XWW4 as per DIN 19573.

3.3. Structural integrity

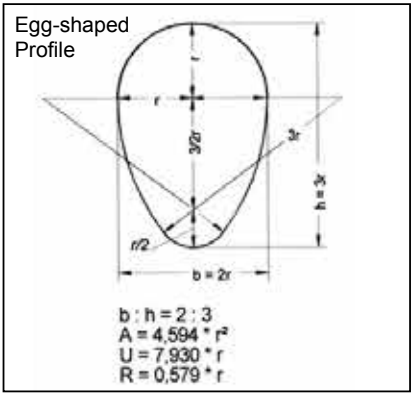
Traffic load can sometimes increase. Even in these cases, structural integrity and future operational safety can be achieved using the wet spraying procedure. For shafts, there is a static calculation model available from HERMES Technologie. In all other cases, statistical analysis should be carried out in the normal way, observing the guidance given in DWA-M 143-7.

4. Calculating surface area

Circular shaft: F = 3.14* Ø m•1 m per linear shaft metre.
The chamber cone is calculated as shaft metres.
Area of coating in m^2 for a circular shaft:

Depth (m) / Ø	1	2	3	4	5	6	7	8	9	10
	m^2									
1.00	3	6	9	12	15	18	22	25	28	31
1.20	4	8	12	15	19	23	27	30	34	38
1.50	5	9	14	19	24	28	33	38	42	47
2.00	6.30	13	19	25	32	38	44	50	57	63

Table: circular shaft coating area



Profile	U m²
50/75	1.98
60/90	2.38
70/105	2.78
80/120	3.17
90/135	3.81
100/150	3.97
120/180	4.76
140/210	5.55

Table: Pipe surface for egg-shaped profile

5. Substrate preparation

5.1. General

The procedure described here deals with the complete mortar coating (rehabilitation) of concrete, ferro-concrete or masonry surfaces in wastewater drainage structures and installations, using hand-held spray equipment. Coating is a general term for one or more integrated layers of coating materials applied to a prepared substrate. The coating can be built up to a thickness from 8 to 40 mm in a single operation (see DWA-M 143-17). Thicknesses greater than that would be considered a new structure. A coating gives a tight bond between a mineral substrate and a coating material, so that every mm^2 is able to transmit compressive and tensile forces.

5.2. Substrate preparation

Substrate preparation in shafts, sewers or installations includes all steps necessary to ensure that the concrete substrate is sound and any reinforcement is in a suitable condition. Substrate preparation includes any necessary removal of concrete in accordance with the rehabilitation plan together with any further removal based upon the condition of the construction that is revealed; as well as exposing reinforcing steel according to the basic solution chosen in accordance with BS8500.
Unless specified otherwise, the contractor must choose the appropriate procedures and equipment so as to ensure that the substrate preparation does not have a detrimental effect on the characteristics and quality of the substrate and also of the reinforcement and its effectiveness.

5.3. Concrete and brickwork substrate

The substrate must be prepared in such a way that a sound and permanent bond can be obtained between the substrate and the concrete replacement system. To that end, the prepared substrate must be:

- free from loose and crumbling material and any existing layers that are flaking away
- free from any cracks that are parallel to the surface, or surface flaking
- free from foreign matter such as previous coatings, release agents, efflorescence, oil, fat, sewer film or vegetation
- free from synthetic or silicate coatings, silicification or other organic or inorganic deposits (incrustations, chalky deposits) that would inhibit adhesion

- free from any running and standing water
- sufficient profile to take the concrete replacement or surface protection system to be applied
- consistently sound

Brickwork before cleaning

Substrate after blasting

Substrate partly abraded after water/sand blasting

Concrete after blasting

Any voids and cavities in the substrate must be opened up and worked on adequately. Unless otherwise agreed, substrate preparation must expose the top of aggregate particles in concrete of > 4mm diameter that are firmly embedded near the surface. In the case of new components, the fine cement layer (laitance) must also be removed.
At the start and on completion of substrate preparation, the contractor must make a visual inspection in the company of the client to check the surfaces to be worked on for cracks, voids, corroded reinforcing steel and other anomalies. If it is discovered that the condition of the structure differs from the assumed condition on which the rehabilitation plan was based, the client must decide, possibly in consultation with the contractor, on what further course of action to take.

5.4. Reinforcement

Once substrate preparation is complete, loose corrosion products must be removed from exposed reinforcement and if applicable from metal fittings. If following rehabilitation method R in the RL SIB DafStb (German Commission for Reinforced Concrete) guideline, de-rusting must be to at least surface preparation standard St 2 or Sa 2, and if following method C in the RL SIB guideline then to at least surface preparation standard Sa 2.

When using ERGELIT-KS2bL, the reinforcemment should be given an additional corrosion protection coat of ERGELIT-KS 1. This is due to the dense and highly alkaline composition of the Special mortar as well as to its finer grain size.

Standard degrees of cleaning for steel reinforcement

6. Substrate preparation procedures

6.1. General

The suitability of the substrate preparation method chosen should be demonstrated at the start of the operation on suitable areas on the surface to be rehabilitated, by treating sample areas in the client's presence, unless experience of similar projects is

already available. For all substrate preparation procedures that might damage the surface of the old pipe, for example chiselling, hammering, milling, extreme high pressure water blasting (> 1000 bar) or flame blasting, the surfaces must be treated with an alternative appropriate procedure, e.g:

TSSR

HDS-jet

- high pressure water jet (hand lance or TSSR)
- water/ solid particles blasting (hand lance or high pressure sand jet)

High pressure water blasting

For oil and fat separators,

- solvents, and degreasers
- hot water for flushing away the cold-cleaning agent should be used.

If air pressure is used, wholly or in part, for substrate preparation, the air should have a residual oil content of < 0.01 ppm and be of breathing air quality. Flame blasting is not used in sewers because of the danger of explosion. Treating the substrate with a chemical process (e.g. using a cold-cleaning agent to get rid of oil) requires the express agreement of the client.

6.2. High pressure water blasting

HTB 400 high pressure water pump delivering 400 bar and 22 l/min or approx 1320 l/hour

Nowadays, high pressure water blasting is one of the commonest techniques used for sewer rehabilitaton.For this technique the following criteria are key:

- water pressure (bar)
- water volume (l/min)
- distance between substrate and jet nozzle

- nozzle type (may be full jet nozzle, flat spray
- nozzle, rotating full jet nozzle
- spray angle
- duration of spray

If a good technical and cost effective result is to be obtained, all these parameters must be taken into account. In the case of sewer rehabilitation, a higher volume of water is always preferable to higher water pressure. This will also flush out extraneous salts from the surface.

6.3 High pressure blasting with the TSSR

The TSSR is a sewer shaft cleaning machine with a slowly rotating nozzle bar equipped with two opposed rotary nozzles, which is slowly lowered and raised in the shaft by a winch.

TSSR

The diameter of the nozzle bar is infinitely adjustable between 50 and 110 cm, and up to 300 cm using extension tubes. In this way the optimum distance of 5-20 cm can be maintained between the nozzles and the shaft wall. The TSSR is powered at approx 400 bar and delivers approx 22 l/min water.

Using the TSSR, the client can be sure that, if the procedure is carried out and recorded correctly, the substrate will be thoroughly blasted. Corroded elements with a strength of up to 12 MPa can be removed.

TSSR HP water blasting, showing rotary nozzle and distance from wall

Structural stability is maintained. These cleaning figures have been examined and confirmed by the IRO (Institut für Rohrleitungsbau Oldenburg). The expert reports are available for inspection. The TSSR cleans at a speed of 8 to 15 min/m., i.e. cleaning and preparing a standard shaft 4 metres deep with corroded shaft walls is normally jet-blasted in approx 35-60 mins. After jet-blasting the structure is washed clean of loose aggregates and debris then flushed away with < 10 bar water pressure (fire hydrant pressure).

6.4. High pressure jet-blasting with hand lance

When using the hand lance, care must be taken to hold the lance perpendicular to the surface to be jetted. The distance between the nozzle and the structure must be less than 10 cm. Strict safety regulations must be observed.


High pressure water blasting

In particular, care must be taken that a distance of > 80 cm is maintained between the nozzle and the operator's body (risk of injury). The operator wears protective clothing and a safety watch is kept by a supervisor throughout the whole job. After blasting, the structure is sluiced down with water below 10 bar (hydrant pressure)

HP water blasting

6.5. Water/ solid particles blasting with the HDS jet (HP sandblaster)

The HDS jet turns 360º around its own axis and is lowered and raised by winch. The HP water pump creates a strong negative pressure in the jet-nozzle on the venturi principle, and this draws the solid particles from a reservoir. 1.5 to 2.5 kilos grit are used per minute, or approx 20 kg per vertical metre for a shaft of 1.00 m diameter.

HDS-jet

The grit is then impelled with such force through the nozzle that it produces a rough surface on glazed sewer clinker brick and new concrete surfaces so that the new ERGELIT coating achieves a permanent mechanical and chemical bond. Synthetic coatings must be completely removed.

A very evenly blasted surface is achieved thanks to the grit (silica free steel slag) with a grain-size of between 0.5 and 1.5 mm being projected across a small, adjustable and regular space between the nozzle and the shaft wall. The HP jet cleans at a rate of 15 min/m.

i.e. Cleaning and preparing a standard 4m deep shaft exhibiting the problems outlined above is completed in about 1 hour. After

blasting, the structure is sluiced down with water below 10 bar (hydrant pressure)

Monsun sand-blasting nozzle

6.5.1. Water/grit blasting with hand lance

Where new or uncorroded concrete or glazed clinker brick has to be coated, the top of aggregate > 4mm must be exposed, using silica-free sand for blasting.

6.6. Dry abrasive blasting with hand lance

Dry blasting with a solid abrasive agent is only used in conjunction with a hand lance. Large compressors are required to provide the necessary volume of air. Air pressure is between 6 and 10 bar. Volume of air should be greater than 5 m^3 per min. In the main, compressors delivering 10-15m^3 are used. It is possible to reduce dust formation by introducing water at the nozzle (wet blasting). Once blasting is completed, abrasive dust or slurry must be washed off from the abraded surface by jetting it with water at a pressure of < 10 bar (hydrant pressure).

6.7. Degreaser

Fat solvent is thinned with water, depending on the degree of contamination, brushed or sprayed on to the surface and washed off after the length of time recommended by the manufacturer. In areas that are heavily contaminated, the degreaser is subsequently removed by jetting with hot water at up to 400 bar. Follow product instructions. If necessary the procedure may be repeated.

Absorbent paper (blotting paper) can be used to check whether deepseated oil is working its way up to the surface. If so, cleaning must be repeated. The entire surface must be free from oil and grease before coating can begin.

7. Testing the surface

The surface to be rehabilitated must be subjected to at least one of the following tests:

- Test pull-off strength at least every 250 m^2 or for each component
- For sample shafts:
- For each operation
- Every 5th shaft, normally
- Every 10th shaft for shafts of the same age in one street or development.

It should be noted that waterlogged surfaces return lower figures for pull-off strength.

pull-off-tester

- Test compressive strength with a Schmidt rebound hammer
- Test masonry joints using needle penetration test
- Use phenolphthalein only to ascertain depth of carbonation or depth of acid attack.

Rebound hammer

Carbonated concrete: concrete not stained violet

Where masonry joints have deteriorated, these need to be raked out to a depth of 20-30 mm (D = 2 x width of joint). Bricks must be sound and clean. If water is penetrating the shaft, this should be sealed by injecting ERGELIT KBi, or using ERGELIT-10SD or ERGELIT-10F rapid. Note that the surface must be damp-wet as per BS8500, and particles should not come away loose from a concrete surface when a hand is rubbed over it.

7.1. Scanning reinforcing steel

The surface of structures and installations is scanned to establish the position, depth of covering and diameter of rebars. This helps to show whether existing reinforcement lies in a carbonated area or possibly in an area damaged by acid attack.

7.2. Testing depth of carbonation

The depth of carbonation in concrete can be determined by a number of methods. The simplest – and the one most commonly used in practice – is to analyse the change in pH value with the help of an indicator solution. Spraying with, for example, phenolphthalein solution shows how far carbonation has penetrated into the fresh fracture surface of the concrete. In these places, the carbonated area remains colourless when sprayed with the solution, whereas the non-carbonated area is stained purple. An area that has been affected by acid leaching can be tested in the same way.

Phenolphthalein solution goes pink-violet in the presence of pH values greater than about 9. Steel inserts should be protected against corrosion at pH values above 9.

Testing depth of carbonation

7.3. Testing the structure's sulphate content

Testing the sulphate and carbonate content of the walls of a structure is carried out by taking borehole samples. Boreholes are drilled to a pre-determined pattern and depth in areas specified by the client. Drillings are placed in moisture-proof sample containers and evaluated in the laboratory. Taking core samples gives a more accurate analysis. 5mm thick discs are cut from the core in the laboratory and the sulphate content is measured for each disc. This must always also be done in an area that is definitely not damaged so that a comparison can be made. Sulphates are an ingredient of concrete, and the proportion can vary. The change must be measured and evaluated.

7.4. Taking core samples

To determine compressive strength, test samples are taken from the concrete of the structure or installation. In addition to indicating compressive strength, the test samples extracted can also be used to determine coating profile, depth of carbonation, soluble chlorides and soluble sulphates content as well as the composition of the concrete.

7.5. Testing the surface tensile strength of the substrate

The test procedure set out in DIN EN 1542:1999 is used to evaluate the surface tensile strength of concrete coatings near the surface.

Surface tensile strength is defined in terms of the maximum pulling force required to produce a break in cohesion in the surface of the concrete, when applied to a defined test area of a test die perpendicular to the plane of the prepared concrete substrate. The purpose of the test is to establish how the concrete surface needs to be prepared for a successful repair.
First a circular groove is cut to define a 50mm Ø test area, which must be dry enough to allow for good adhesion. The exact diameter must be measured and recorded. The concrete surface must be worked over with a steel brush and a grinding disc in order to remove the surface cement layer (laitance). Experience shows that the latter does not constitute a good substrate for subsequent coating.
For the surface tensile strength test, at each test site three cylindrical steel discs (test dies) 50mm in diameter and 30mm thick are stuck with MMA (methyl methacrylate adhesive) or polyurethane-based adhesive to the surfaces to be tested, and pulled off with a tensile bond strength testing apparatus. (For pulling devices, see DIN EN 10002-4, Class 2).
The number of tests required to measure surface tensile bond strength is to be decided by the client with regard to the structural conditions. For target values for surface tensile bond strength, refer to those given in DWA-M 143-17.

For shafts, this test must be carried out for every 5th shaft, and in the case of shafts built at the same time and with surfaces of the same appearance, every 10th shaft. In other structures, every 250 m^2 or on dissimilar surfaces. In the case of shafts, in particular, a smaller number of tests may be carried out with the client's agreement. Determining compressive strength with a rebound hammer must always be carried out, and may indicate which in areas you can reduce the number of pull off tests.

7.6. Testing substrate compressive strength

The quality of concrete is judged amongst other factors by its compressive strength. This has a direct bearing on the load-bearing characteristics and durability of a concrete structure. The non-destructive measurement of compressive strength can be made using a Schmidt hammer. The rebound hammer strikes the concrete with a defined amount of energy. A body will rebound to a greater or lesser degree depending on the hardness of the concrete in question. The apparatus measures this rebound. With the aid of the appropriate horizontal or vertical selection curves, the structure's compressive strength can be read off against the rebound value achieved.

8. Substrate preparation

8.1. General

For the necessary preparatory work on the substrate prior to coating, only materials should be used whose properties are listed in technical data sheets and which comply with DIN 19573 and DWA M 143-17 are used. Basically only WW mortars must be used. This can be verified from the relevant performance information or, where there are special requirements, by supplementary test certificates. ERGELIT-KS1 WW coating mortar and ERGELIT-KBi injection mortar have been accorded DIBt approval. The individual materials are processed in accordance with the instructions given by ERGELIT/HERMES. The processing instructions and the technical data sheets are made available for inspection on site. Early strength up to about 5-10 N/mm^2 can be measured on site using a penetrometer. A record is kept of the execution of the work and the materials used. Work on the

Penetrometer

concrete renovation or surface protection can only begin with the client's approval. (See DWA M 143-17.)
The coating surfaces must be thoroughly wetted at least 24 hours before mortar is applied, if they are not normally in direct contact with water. In closed systems, shafts and pipes such preliminary wetting is only necessary in exceptional cases (surface water drains or open culverts in a street), but it is usually unavoidable in open structures. Surfaces should be matt-damp to wet as per RiLi SIB. By 'matt-damp' is meant that the surface looks slightly moist but without any shiny water film.

The pores of the concrete substrate must not be saturated, i.e. surface water droplets must be absorbed and the surface must quickly look matt. 'Wet' means that there is water in the pores of the concrete but there is no surface film of water. Strong sunshine and good ventilation can lead to rapid drying out of the surface during coating. If this occurs, the surfaces must be dampened again before mortar is applied. If necessary, moisture should be increased in the ventilation air (approx. 95% relative humidity) so that moisture is not drawn out of the fresh coating. The thinner the coating, the more susceptible is the fresh mortar layer. Suitable steps must be taken to ensure that areas that have already been prepared for coating are not soiled again. Areas that have not been cleaned must be cleaned before coating. The substrate must still be rough: depth of roughness must be at least approx. 1 to 2 mm.

8.2. Mineral sealing slurries

ERGELIT-DS is the product used for sealing rising and penetrating moisture. This is a cement-based mineral early strength all-in-one sealing mortar improved with organic additives. This is not a coating mortar in the terms of DWA M 143-17. Its specifications according to DIN 19573 can be verified in the performance data.
ERGELIT-DS is mixed with a power mixer or an agitator following the instructions given by HERMES Technologie, adding water at a rate per sack as indicated by HERMES. The WW slurry sealant can then be wet-sprayed onto the substrate. At least two coats are always applied in order to avoid gaps. The combined thickness is between from about 2 to 3 mm.

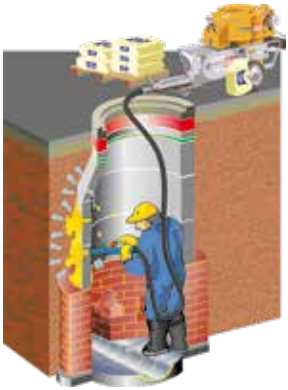
9. Repairing shafts and drainage systems

9.1. Injection

Water ingress at pipe connection

In cases of infiltration (water ingress) and exfiltration (water egress), cement-based materials are used to provide a seal. The reason lies partly in the fact that these have no harmful effect on the groundwater – especially important in water protection zones – and partly in the ease with which they can be handled and in their universal applicability.

9.1.1. Cement mortar injection



Injection: process overview

For example, using ERGELIT-KBi and ERGELIT 10SD, a structure can be sealed permanently even where there is running ground-water and heavy water ingress. 14mm Ø holes (or holes of the diameter of an injection packer) are drilled in the shaft wall about 10cm around the defective spot. ERGELIT-KBi dry mortar is mixed with water to a soft plastic to fluid consistency and injected at < 1 bar pressure with an injection lance. (However, in loose sand, using cement-based pressure grouting suspension is only possible in exceptional cases.) It is often enough to drill 4 holes per m2 or a 50-100 cm grid for an extensive area of leaks; or 2 to 3 holes per linear metre of shaft depth in the leaky area.

Injection lance

Injection packer inserted

Injection lance with lamella drive-in packer (right)

Injection points should be spaced about 1 metre apart. The number of injection sites needed will vary according to local requirements. When using injection packers, the packer's diameter diameter must be taken into account. (See also DWA-M 143-17). On average, 200 to 300 kg dry mortar are needed per shaft. The actual requirement depends very much on the strength of the leak and the soil conditions. Application rate depends on the scale of the damage, depending on the structure or pipe. The mortar to be used must comply with DIN 19573 in having a high level of thixotropy and colloidal properties. ERGELIT-KBi is impermeable and has a water penetration depth of virtually 0mm at 2 bar water pressure. Its environmental compatibility is confirmed by its DIBt certification.

Thanks to its colloidal properties and the high cohesion of the separate particles, it has also been successfully used in a number of projects where there was running groundwater. Injection with ERGELIT enables a successful seal to be made against invasive groundwater, in particular where groundwater penetration is heavy and always where sealing gels fail to work.

For this, the consistency can be adapted to each situation, between stiff plastic (water-solids ratio approx. 23%) and highly fluid (w/s ratio approx. 35%). In exceptional cases, where the mortar is being injected into quite fine gravel or sand, the water/solids ratio can be increased up to 50%. In that case, the seal is produced in combination with the natural sand. The quantity of mortar injected should generally be less than 10 l/min: the slower the injection rate (e.g. 4 l/min), the more material can be forced into the surrounding ground.

Greater injection speeds should only be used where it is suspected there are voids. For larger cavities that are not filled with water, Dämmer® or Blitzdämmer® can be used. The WW injection mortar is mixed in a powered mixer. This could be a two-paddle whisk, a continuous mixer with a reduced flow rate or a pan mixer. The mixed mortar is fed into the worm pump and pumped to the injection lance by a UE4 rotor-stator (4 l/min).

The UE8 rotor-stator (8 l/min) is only used for injecting larger cavities. Since there are usually slight delays at the start of the injection process, once the first batch of mortar has started to stiffen it is mixed again without any additional water added. After that, ERGELIT-KBi can be pumped immediately after mixing. Mortar is injected through a packer until the pressure gauge on the injection lance shows a rise in pressure. The pumping must then be stopped immediately. If pressure drops again after that within 1 minute, more mortar can be injected. If the pressure at the injection lance does not drop, the lance must be carefully detached. (The man on the lance must be wearing suitable PPE). The packer is closed off, the injection lance is attached to the next packer and injection resumes. This continues until all the packers have been injected and the cavity has been filled or the leak has been sealed. It may be that further packers may have to be placed at intermediate points. During injection, packers that have not yet been injected must be left open. They are only closed if WW injection mortar leaks from them.

9.1.2. Injecting with synthetic resin

Defective shafts and man-entry sewers can be sealed with the HERMES-WS and HERMES-WS Quick cartridge system. Injection is carried out on the inside of the structure, with the actual sealing taking place on the outside.

The resin is injected through to the back of the structure, using a static mixer and drive-in packer with a one-way valve. The fluid material penetrates the finest cracks and the pore space in the surrounding ground. The hardened resin seals the damaged area permanently. It is particularly useful in drain shafts and man-entry sewers.


Injecting resin


Resin injection: process overview

Product advantages:

- Seals against flowing water and water inflow through walls. Very easy to use.
- No internal shuttering required
- Sets immediately
- High chemical strength
- Ecologically safe
- CFC-free and halogen-free

Mixing:

Balanced quantities of resin and hardener are delivered in double cartridges and are mixed under pressure by static mixer in a HermesGun. The cartridges must be completely emptied before being disposed of. There are mechanical, pneumatic and electric cartridge guns. For pneumatic cartridge guns, the pressure must be below 3 bar.

9.2. Manual spot sealing

Even heavy sporadic leaks can be quickly and permanently sealed using “plugs” of ERGELIT-10SD. For this, 25 mm Ø holes are bored 20-30 mm deep at the sites of water infiltration and rapid-setting ERGELIT mortar is mixed with water to a kneadable consistency and pressed into the holes.

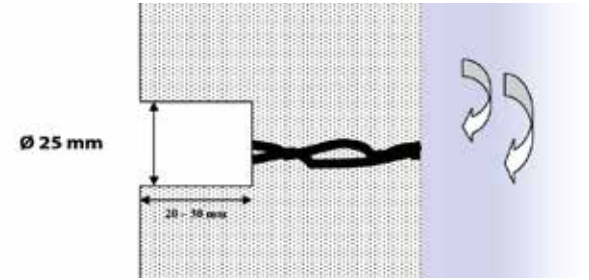


Diagram showing hole bored in preparation for plugging leak

Care must be taken with the correct water ratio when mixing (approx. 0.2 water/solids). ERGELIT-10SD sets so hard after 1 – 2 minutes that it will securely withstand the pressure of the water. Only mix sufficient mortar at a time that can be applied with one hand. ERGELIT-10SD has good corrosion resistance and does not shrink in the area of application. The adhesives in ERGELIT-10SD ensure a firm grip on the whole of the damaged area. Larger holes are filled in gradually from the edge to the centre. In this way, the leaking hole is finally closed. The surface of the repair mortar must be roughened so that the subsequent coating can make a good bond. It has proved

Water ingress

Drilling borehole

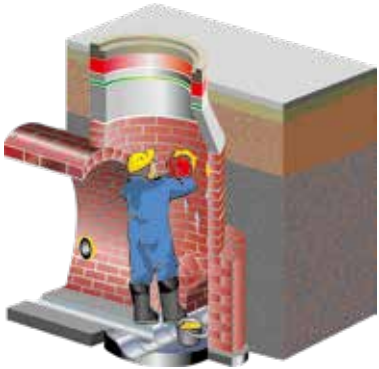
ERGELIT-10SD

Apply pressure

Maintain pressure for short time

Leak sealed

useful to drill relief boreholes in the area around large, jagged leaks. Such boreholes focus the water pressure at the areas of deterioration and can themselves be more easily sealed later. Where leaks take the form of exfiltration, where there are varying groundwater levels or where masonry is permeable,



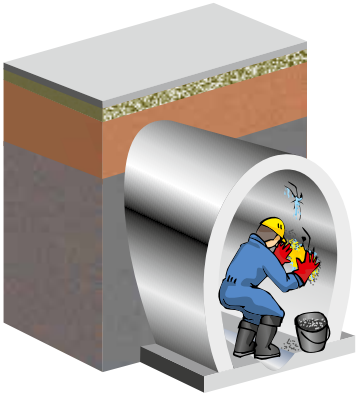
it is recommended to give the structure a complete coating.
That is the only way to guarantee the impermeability of the structure.

Extraneous water infiltration

Slight leaks (infiltrating water) can be sealed using super rapid dry mortars like ERGELIT-10F rapid, which are simply rubbed into the wet substrate.

This is normally a question of temporary sealing. For a permanent rehabilitation in these cases, a subsequent coating is necessary.

Applying ERGELIT-10F rapid



9.3. Grouting cracks

Cracks in structures and installations allow corrosive agents to attack the concrete microstructure and steel reinforcement. This can result in a breakdown in the concrete bond or the concrete to steel bond. The structure's loadbearing capacity is impaired or may even fail. Furthermore, cracks enable moisture to penetrate.

Drilling injection holes

Injecting with ERGELIT-KBi

The following methods are available for dealing with cracks:

- filling the cracks to prevent pollutants getting into the structure
- sealing the cracks to prevent damp penetrating the structure or water leaking into the structure
- caulking the cracks with an expansible, elastic sealant in order to close them up flexibly but permanently
- filling the crack tightly in order to produce a joint with both tensile and compressive strength

For that, the following procedures may be used:

- Impregnating or filling cracks, not under pressure (not usual in sewer rehabilitation)
- Injecting, filling cracks under pressure

The following materials can be used, depending on the procedure:

- Epoxy-resin (impregnation, injection to produce flexible but tight joints e.g. Hermes-WS Quick for tight, rigid joints)
- Polyurethane resin (injection for a tight repair of both flexible and rigid joints)
- ERGELIT WW mortar (cement paste, cement suspension) (injection to produce a tight joint)

The technique and materials used comply with the requirements of DWA-M 143-8 (2017 edition) and DIN 19573. The crack is first opened up 5mm-10mm wide and about 2 x width deep. All dust or sludge must be flushed out under pressure. The opened crack is now filled by trowel. Holes are drilled into the crack at an angle every 100 mm , packers are driven in and the crack injected with ERGELIT-KBi. All packers that have not yet been injected are left open as vents. When the whole crack has been filled, the packers are cut off and trowelled over with ERGELIT-10SD

9.4. Joint sealing

Rigid joints between individual concrete sections in pre-fabricated shafts or other joints in structures and installations can be repaired. For this, ERGELIT-KS1 or ERGELIT-10S spec or ERGELIT-SBM are used. See the relevant technical information sheet for how to mix and apply.

It may be necessary to open up a joint (1cm wide and 2cm deep). Depth of joint = 2 x width of joint. Care must be taken to roughen the edges of the joint, possibly with a hammer or by sand-blasting.

9.4.2. HERMES Pressure pointing

Often it is just the horizontal and butt joints in masonry that are corroded. In that case, the joints simply need to be raked out 2-3 cm deep. They are grouted with a WW grouting mortar before coating is carried out. ERGELIT-KBi or ERGELIT-KS1 are suitable. The mortar is injected under pressure into the joints in the masonry. Because of the restricted space, the mortar is pumped at about 4 l/min

ERGELIT Pressure grouting

Cleaned-out joints

Flow spread measured on a Hägermann table

Pressure-grouted and cleaned clinker brick

Pressure-grouting in shaft using ERGELIT-KS1

Pressure-grouted shaft before coating

9.5. Corrosion protection for exposed reinforcement

After cleaning the substrate to be coated, any loose rust on exposed reinforcement and built-in ironwork must be removed. Corrosion protection is achieved by applying a waterproof coating directly to the surface of the reinforcement. For this, the exposed reinforcing rods or built-in ironwork must be treated as per the maintenance method selected under the DAfStb guidelines:

- Maintenance method R: surface preparation grade Sa 2 as per DIN EN ISO 12944-4
- Maintenance method C: surface preparation grade Sa 2.5 as per DIN EN ISO 12944-4

Standard degrees of purity for steel reinforcement

Cement-based ERGELIT-KS1 is used for coating. The mortar is brushed manually onto the prepared reinforcement at a minimum thickness of about 1 mm. Coating is applied in two operations. Care must be taken to ensure that the upper surface of the reinforcement is completely covered, and that reinforcement spanning cavities is well bedded in the spray mortar without voids. Start by spraying the reinforcement from all angles. The total coating thickness must be > 10 mm.

BSC corrosion after cleaning

Where reinforcement and concrete meet, coats must overlap.
Care must be taken with the temperature of the substrate when processing the coating: as a rule, not below +3ºC, not above +30ºC. The substrate temperature must be recorded.

9.6. Post-installation of rebar connections

9.6.1. Reinforcement replacement

Corroded steel reinforcement

Where reinforcement steel has been heavily corroded or even corroded completely away, the post-installation of replacement reinforcement can be agreed on by the planning engineer in the light of the static requirements of the structure. There are various possibilities for fixing this replacement reinforcement onto steel that is not yet weakened by corrosion.
(Take care with bond lengths, and use as small a diameter as possible.) If this is not feasible, installation is effected as described

Rebar inserted

in a system authorised by the DIBt, with reinforcement rods anchored retroactively, using the appropriate injection mortar, ERGELIT-KBi. The distance between rods, the length of overlaps and the depth at which rods are set are to be specified by the planning engineer. (See also DIN 1045.)

9.6.2. Additional reinforcement when spray coating with mortar

If the loadbearing capacity of a shaft or sewer has to be significantly increased, reinforcement based on static calculations is often required. We distinguish between:

- Carbon fibre reinforcement
- Steel reinforcement

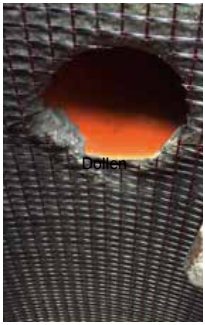
Steel reinforcement

However, as long as the reinforcement is not structural, a shear test certificate can be omitted.

9.6.2.1. Shear strength

W W - c o a t i n g mortar	Approx. shear strength N/mm² ca.
ERGELIT-KS1	> 2.5
ERGELIT-KS2	> 2.5
ERGELIT-KT10	> 2.5
ERGELIT-KT40	> 2.5

Table: Shear strength



Carbon fibre mesh fitted in shaft

If a static analysis (shear check) shows that a higher degree of shear strength is required, shear anchors must be fitted. The stress analyst will specify the diameter, number and distance apart.
The shear anchors are attached to the loadbearing concrete with adhesive or wallplugs.


Dollen

9.7. Climbing irons

Depending on the contractual specifications, climbing irons are either masked off or removed before coating begins, or the sprayed mortar is cleaned off afterwards.

9.8. Reprofiling

The elimination of defective areas or complete re-profiling of the substrate of the structure or installation to be coated is carried out following the manufacturer's processing instructions for ERGELIT-KS1, ERGELIT-KS2 or ERGELIT-SBM.

9.9. Steps/ benching/ channels

The access steps, benching, channels and inflow and outflow points are repaired or reconstructed on the basis of the record of defects drawn up. Channels and benching can also be included as part of the coating renovation process.

The materials used in carrying out this stage of the work, are to be used as specified in their material data sheets. The processing instructions are to be made available for inspection on the work site. The execution of the work and the materials used are logged.

The work can be carried out using sewer bricks laid and pointed with

ERGELIT-KS1, ERGELIT-KS2, ERGELIT-SBM or ERGELIT-KT10. Care must be taken to wet the tiles or bricks. Another possibility is to use Predl Flexliner, fixed in place with a screed of ERGELIT-fix 35

10. Wet spray procedure

10.1. General preparation / tools

Before the actual coating, all areas that must not be splashed with ERGELIT mortar must be masked off. Then the substrate to be coated must be tested:

The substrate must be cleaned as described above. As required in the materials data sheet, the substrate must be pre-wetted to 'matt moist'.

That also applies where coatings are made up of several layers applied in separate operations.

The ambient conditions in the area of the substrate must also be assessed and recorded. The ventilation of the work area must be planned and put in place. As the work progresses, attention must be given to the follow-up treatment of the surfaces that have already been coated. (See also section on Follow-up treatment.) The fresh coating must not be allowed to dry out at any time during the first 28 days or until the sewer etc. is returned to service. The surfaces must not be allowed to become light-coloured (i.e. dry) before return to service.

RH30 XL worm pump

RH30 worm pump

Worm pump with pan mixer

Rotary piston pump

10.2. Equipment

Equipment for dense flow spraying.
Hand-held spray nozzles are used for wet spraying. For conveying fresh mortar, worm pumps or double-piston pumps are used, principally. Rotary piston pumps do give a more even throughput, but there are very few manufacturers.
In comparison with conventional concrete pumps, these pumping systems fulfil the additional need for the most even and uninterrupted flow of mortar possible, to guarantee the most even spray pattern possible.
Worm pumps can generally deliver mortar through the hoses at up to 40 bar. There are few versions that can pump at up to 70-80 bar. In all worm pumps, backflow occurs as pressure rises. That does not happen with double-piston pumps, as long as the drive-motor is powerful enough and its rotational speed is constant. Rotary piston pumps can convey mortar at up to 100 bar.

RHM404 continuous flow mixer

RH100 pan mixer

ZK150 pan mixer

10.3. Mortar hose length

Hose length - m -	Diameter -mm-	Operating pressure - bar-
10	19	40
40	25	40
80	32	40
100	38	60
150	44	100
200	50	100

Table showing requisite hose diameter for length of hose needed

Normally, hoses with two textile reinforcement layers are used, or 3 layers above 40 bar. In exceptional cases, hoses with steel inner linings are used. These have the advantage that they cannot kink so easily. Test pressure is twice as great as operational pressure (pump pressure), and burst pressure is 3 x operational pressure. Above 40 bar operating pressure, lengths of hose are connected to each other and to the pump with screw couplings.

Quick couplings with 2 cams are used. There should always be a male fitting at the pump outlet, since that suffers less wear than a female fitting. After a blockage, the split pins on the cam levers on the female fitting should be inspected and replaced if they are bent.

10.4. Pump pressures

Delivery volumes		Hose Ø - mm -	Hose length - m -	Pump pressure -bar -
Pump output - l/min -	Hose end 20m - l/min -			
7	6	25	10	4
10	9	25	10	5
14	13	25	10	7
16	15	25	10	8
20	18	25	10	10
24	20	25	10	13
28	24	25	10	14
36	28	25	10	15
14		35	10	4
16		35	10	5
20		35	10	5
24		35	10	6
28		35	10	6
36		35	10	8

Pump pressures relative to delivery volume, hose diameter and length of hose.

10.5. Wet spraying: Mixing and pumping

The following sequence should be followed closely. Health & safety rules for wet spraying cement-based mortars must be observed.

10.6. Preparatory steps

10.6.1. Put the pump in position and connect to power supply; or fill with fuel where power is by combustion engine.

10.6.2. Get mortar ready, under cover. Prepare high pressure pump and flushing hose.

10.6.3. Put mixer in position.

10.6.4. Lay out hoses, sponge balls, flushing hose, power drill for cleaning, with 16 mm Ø drill bit longer than 40 cm, and 30 cm long DN 6 mm screwdriver.

10.6.5. Choose suitable spray nozzles, possibly 10 mm, 12 mm or 14 mm Ø. 14 mm where size of aggregate > 3-4 mm


Spray nozzle


Spray nozzle

10.6.6. Connect mortar hose to spray nozzle.

10.6.7. The last 10 metres must be DN25 mm hose.

10.6.8. The rest of the hose connected to the pump can be wider, e.g. DN32 mm. See also hose length/ diameter table.

10.6.9. Connect the air line to the compressor.

10.6.10. It is essential to install an oil/water separator between the compressor and the air line.

10.6.11. Approx. 100 metres of hose must be arranged upstream of the oil/water separator in order to reduce the temperature of the air and thus separate out the excess moisture as condensed water. Alternatively, an air-dryer may be used.

10.6.12. Start up the compressor and release air to the spray nozzle.

10.6.13. The air supplied must be dry.

10.6.14. For the last 10 metres, use rubber bands to tie the air-line and the mortar hose together every 1m 50.

10.6.15. For the remaining lengths of pipe up to the pump, tie the air-line and the mortar hose together witrh rubber bands every 5 metres.

10.6.16. Shade hoses, water and mortar in the summer.

10.6.17. Lubricate with water all equipment and hoses that come in contact with mortar.

10.7. Mixing and pumping

10.7.1. When using a batch mixer (e.g. RH100), firstly empty two sacks of ERGELIT mortar into the mixer then add all the water required for the mix . (See relevant TDS for amount of water per kg)

Finally add the remainder of ERGELIT mortar.

10.7.2. Mix the ERGELIT for 3-5 minutes. The resulting mix must always be smooth.

10.7.3. If necessary, add more water.

10.7.4. When using a continuous flow mixer (e.g. RHM 404) firstly fill hopper with selected ERGELIT mortar and adjust the water dosing on the flow mixer. Note the flow rate and measure the quantity mixed per minute to confirm adherence to relevant TDS water content. To ensure uniform consistency of the mix keep the hopper topped up with dry mortar.

10.7.5. Measure consistency on a Hägermann spread table and if necessary modify the consistency of the fresh mortar according to the specific situation.

10.8. Pumping the mortar

10.8.0. In a worm pump, the soft stator is used with coarse (approx. 4 mm) grit, and the hard stator for fine (approx. 1 mm) grit.

10.8.1. Before the freshly mixed ERGELIT mortar is fed to the pump, a thin slurry should be run into the hoses, depending on the length of the hose.

10.8.2. This slurry should consist of just cement and water.

Alternatively soft soap can be used. Its consistency should resemble yoghurt: creamy to fluid, but not watery.

10.8.3. For DN 25 and DN 32 hoses, about 0.5 litres is needed for every 10 metres of hose.

10.8.4. Then feed the mortar from the mixer to the pump. Hang a bucket under the pump outlet.

10.8.5. Start up the pump. Pump until mortar of the right consistency comes out at the pump outlet.

10.8.6. Wipe the outlet clean and connect the mortar hose to the pump.

10.8.7. Then proceed to pump at slow speed (about 5-15 litres/minute).

10.8.8. Hold the free end of the hose in half a bucket of water and look for air bubbles. As long as air bubbles are visible, the hose is being filled with mortar. If there are no more air bubbles and no mortar comes out although the pump is working, a blockage may have built up in the hose. In that case, stop the pump immediately and look for the cause. Caution! If water leaks gently at a coupling, you must assume there's a blockage in the mortar.

10.9. Spraying

10.9.1. Before the mortar emerges at the nozzle, the air supply must be opened up a little and the excess slurry caught in a bucket.

10.9.2. As soon as the mortar at the spray nozzle is the same colour as the mortar in the pump and is coming at a suitable, i.e. sprayable, consistency, spraying can begin.

10.9.3. The 1-2 mm thick bonding course is sprayed at about 5 bar air pressure.

10.9.4. During operations, never close the grout shut-off valve (where fitted) on the spray lance.

10.9.5. The grout shut-off valve is only used when a hose is being pulled up from the shaft, or lowered into it, vertically over a man's head. It is not used for any other purpose. It should be cleaned and treated with rust inhibitor after each use.

Sprayer's helmet

10.9.6. When spraying is finished or interrupted, always turn the mortar pump off first and then the air-line. Otherwise mortar can find its way into air line through the narrow air nozzle and block it.

10.9.7. The mortar coating is sprayed on up to 2 mm thick, using a roughly circular motion and at about 3-5 bar air-pressure.

10.9.8. Hold the spray nozzle perpendicular to the surface being coated.

10.9.9. After that, the mix can be adjusted somewhat stiffer.

10.9.10. Air pressure can be reduced somewhat to 2-4 bar in order to minimise dust production.

10.9.11. In this way the desired total spray coating thickness can be built up.

10.9.12. If there are exposed reinforcement bars, any gap between the substrate and the rebar must be filled to begin with. The mortar should be sprayed from both sides of the rebars so as to leave no voids.

10.10. Cleaning the equipment

10.10.1. At the end of spraying the hoses must be cleaned.

10.10.2. Release the pressure of the mortar in the hoses, by running the pump in reverse for 1-2 seconds. The pressure gauge must read 0.

10.10.3. When the pressure gauge reads zero and there is no more pressure in the hose, the mortar hose is uncoupled.

If pressure cannot be released, lay a thick cloth around the coupling and undo the coupling so that spray mortar is caught in the cloth. It is essential to wear protective glasses.

10.10.4. A sponge ball is inserted into the mortar hose at the pump.

10.10.5. Caution! The high pressure water pump is used to flush the sponge ball through the hose in order to clear all mortar from the hose. Hold the end of the hose in a tub or bucket to catch the sponge ball. In this way, no-one is injured when it is expelled at speed. Hold the hose securely! The end of the hose can recoil and strike with force when the sponge ball is expelled, or shortly before.

10.10.6. This step must be carried out at least twice.

10.10.7. In the end, water must run clean and clear from the hoses.

10.10.8. The hose must never be flushed through simply with water – always flush thoroughly with water and a sponge ball.

10.10.9. Even if the mortar hose is not flushed out with the high pressure pump but with the mortar pump (once the pump hopper has been filled with water!), a sponge ball must always be used to clean the hoses.

10.10.10. When using the high pressure pump, a 2 metre long rinsing hose with a safety valve must be used. The safety valve should be limited to a maximum 80 bar. This must be checked when being used for the first time.

10.10.11. The mixer and the pump must then be cleaned. All metal parts must be protected by spraying with rust inhibitor, e.g. WD40.

10.10.12. Never grease the stator or wet it with rust inhibitor. Protect both rotor and stator with silicone or soft soap and reassemble.

10.11. The products

10.11.1. WW coating mortars

Type	Grit size mm	Binding agent	Stator	Nozzle Ø mm
ERGELIT-KS 1	1	high	hard	10
ERGELIT-KS 2	1	high	hard	10
ERGELIT-KS 2b L	2-3	high	soft	14
ERGELIT-KT 10	1-2	medium	hard	10
ERGELIT-KT 40	4	medium	soft	14
ERGELIT-OED 35	3-5	high	soft	14
ERGELIT-KBF 40	4	medium	soft	14

Table: Minimum nozzle size

Hose diameter	Quantity of mortar in litres per metre	Quantity of mortar in kg per metre
25 mm - 1“	0.5	1.1
32 mm - 1 ¼ “	0.8	1.7
38 mm - 1 ½“	1.2	2.5
50 mm - 2“	2.0	4.2

Table: Quantity of mortar per metre of hose

Measure the flow spread of ERGELIT WW coating mortar in mm about 5 minutes after mixing.


Hägermann flow table


Measuring flow spread


Measuring flow spread

ERGELIT-KT 10 mortar

Water:solids	10%	11%	12%	13%
Flow spread (mm)	105	113	125	145

ERGELIT-OED 35 mortar

W/S	12%	13%	14%	15%
Flow spread (mm)	111	127	140	154

ERGELIT-KT 40 mortar

W/S	9%	10%	11%
Flow spread (mm)	120	160	> 290

ERGELIT-KS 1 mortar

W/S	13%	14%	15%	16%
Flow spread (mm)	105	125	160	185

ERGELIT-KS 2 mortar

W/S	15%	16%	17%
Flow spread (mm)	140	165	210

ERGELIT-KS 2b L mortar

W/S	14%	15%	16%	17%
Flow spread (mm)	100	125	140	160

Table: Flow spread

10.11.2. Required flow spread for ERGELIT mortars relative to distance conveyed and hose diameter

Type	Conveying Length (m)	Hose diameter (mm)	Flow spread from- to (mm)
ERGELIT-KS 1, KS 2, OED 35,	up to 20	25	120 - 130
	20 - 40	25	120 - 140
	40 - 60	25	140 - 160
ERGELIT-KT 10, KT 40, KBF 40 ERGELIT-KS 2b L	bis 20	25	150 - 160
	20 - 40	25	155 - 170
	40 - 60	32	155 - 170
	bis 20	25	160 - 170
	20 - 40	25	160 - 170
	40 - 60	32	160 - 170

Table: Consistency required for distance required to be pumped

10.12. Creating the bonding course

A bonding bridge of the coating mortar is first applied. Bonding coat and final coating are the same mortar. The mortar is made up to a soft/plastic consistency (see the technical data sheet for the highest volume of water permitted) and sprayed on with a circular motion at 4-5 bar air pressure .

The bonding coat should be approx 1-2mm thick. If the substrate to be coated exhibits surface defects or cavities, these should then be levelled out with the ERGELIT mortar or filled when spraying the base coat. .

10.13. Mixing WW coating mortar

The appropriate mortars are mixed as per the particular technical information sheet, taking care always to put the water first into the mixing vessel. Use only drinking water. It is essential to adhere to the percentage of water laid down, which is always related to the dry weight of the dry mortar.

WW coating mortars for spraying are usually mixed in powered mixers. A trough mixer, a pan mixer or a continuous flow mixer are used. Trough mixers and pan mixers differ in their vertical or horizontal mixing shaft. The quality of the mix in a flow mixer depends on the mixing quantities per minute and on the mixing duration. Longer mixing tubes are preferable to shorter ones. Water is added by spraying the mixing water onto the dry mortar. Long interruptions to the mixing process should be avoided. The mixer should never stand idle for more than 5 minutes. When work is interrupted, always power on again briefly and mix up a few litres of fresh mortar, possibly with a somewhat softer consistency.

.

10.14. The following mortar types are used:

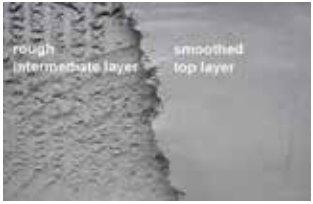
- ERGELIT-KS 1
- ERGELIT-KS 2
- ERGELIT-KS 2bL
- ERGELIT-KT 10
- ERGELIT-KT 40
- ERGELIT-KBF 40
- ERGELIT-OED 35

10.15. Mortar consumption

About 2.1 kg dry mortar is needed per m^2 per mm thickness of coating. For process-related losses (fresh mortar left in the mixer, pump and hoses), one can reckon on 15% for small spray operations, 10% for medium operations and 5% for large-scale operations. For coating thicknesses of around 10 mm one can reckon on at least 10% losses. This includes rebound losses.

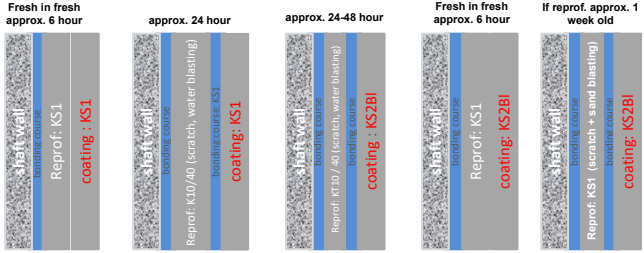
10.16. Coating

Spray mortar is applied in layers, either in one operation consisting of repeated spray-coats over the same area, or in a subsequent operation after an interruption. If operations are interrupted for some time, the surface must be roughened with a toothed trowel (10 mm teeth), cleaned again and re-wetted. How much mortar can be applied in one operation depends on a number of different factors:



rough intermediate layer/ smoothed top layer

- Capacity of mixer and pump
- Length of hoses
- Necessary interruptions to operations
- Accessibility
- Mortar processing time
- Water evacuation
- Ventilation
- Production of dust



Substrate treatment after interruption to operations

40 mm coating of fresh-on-fresh ERGELIT-KS2 sprayed onto vertical surface

10 mm thickness of freshly sprayed coating of rough (spray-ready) surface

Surface roughened with a toothed trowel when work is interrupted between two layers.

10.17. Penetrometer


Penetrometer

For measuring early strength. By using a shotcrete penetrometer, the freshly sprayed mortar is tested with a needle on site. The measurement of strength will lie between 0.2 and 0.9 MPa. For sewer rehabilitation, the penetrometer gives useful results. Take the penetrometer and place the point of the needle against the concrete mortar sample to be tested. Apply gradual pressure until the needle penetrates the sample up to the 1 inch (25.4mm) mark on the shaft. At least ten tests must be carried out for each concrete mortar sample to be tested: do not consider the two lowest and higher values, then calculate the average of the remaining six value as result of the test.
The strength is read off on the scale. This method allows compressive strength to be measured by hand up to 8-10 MPa, so that a good estimate can be made of a coating‘s water loadbearing capacity. One can expect a figure of from 2 MPa where water flow is laminar.

10.18. Spray shadow

The creation of cavities in the mortar, e.g. behind reinforcement, is a serious problem in particular when spraying mortar to renovate concrete. In the end, only an experienced spray operator can minimise the degree of spray shadow by skilful application of spraying technique. In order to avoid spray shadow around reinforcement, the space behind the reinforcement must first be filled. The area between rebars is then sprayed level. This demonstrates once again the importance of the spray operator as a decisive factor in achieving high quality mortar spraying.

10.19. Degree of rebound

The reduction of shotcrete rebound in the spraying process is one of the most complex challenges presented by the shotcrete technique. With ERGELIT mortars the difficulty is much reduced, thanks to their composition. However, the spray operator is clearly the most important factor. His skill and experience play a crucial role when it comes to the degree of rebound.

Rebound is greater when spraying the bonding bridge than when applying the remaining thickness of coating. As soon as a 2 mm thick bonding course has built up, the aggregate hits a soft bed that reduces rebound.

Factors influencing the degree of rebound:

- Operator's skill and experience
- Direction of spray (up, down, horizontal)
- Spray equipment (air pressure, nozzle, spray capacity)
- Spray method (dry or wet spray mortar)
- Spraying mortar formulation (aggregate, grain size distribution, fibres, proportion of binder)
- Spraying mortar (degree of early strength, adhesion, coating thickness)
- Condition of substrate (flatness, adhesion properties)
- Without actual measurement of rebound taking local conditions into account, rebound can be only roughly estimated:
- 20 - 30 % rebound when dry spraying vertically upwards
- 5 - 15 % rebound when wet spraying vertically upwards
- 3 - 5 % rebound when applying ERGELIT-KS1 or 2 vertically upwards
- 3 - 8 % when applying ERGELT-KT 40n or KS 2b L vertically upwards

10.20. Re-use / Disposal

Spray mortar rebound is basically concrete for recycling, with all the ingredients of the original mix but in a different distribution. In sewer rehabilitation, rebound material is disposed of. The quantities are too small to be worth reconditioning.

10.21. Dust production

Dust is produced whatever type of spray mortar is used. However, the quantities and types of dust vary enormously. Dry spraying mortar creates a serious problem, since by their nature the ingredients have a strong tendency to produce dust. Dust production with dry spray mortar is about two to four times that of wet spray mortar.

10.22. Spray technique

- adhesive power of the spray mortar formulation
- spray output selected
- direction of spray (upwards or horizontal)
- condition of substrate or base layer
- obstructions (reinforcement, built-in parts, access)
- spray procedure and compressed air settings

Different spraying directions must be tackled in different ways. When spraying downwards from above, any thickness can be sprayed. ERGELIT mortars may be used in this situation.
When spraying horizontally, the coating thickness can be build up in thin layers, in stages. Even here, rebound spray must be removed from the ground before the next layer is applied.
When spraying overhead, the weight and the adhesive strength of the mortar work against each other, so that thinner layers have to be

built up. Overhead, a 10 mm thickness is possible for all ERGELIT mortars. Where conditions are particularly favourable, layers of up to 30-40 mm can be achieved, but this requires a very experienced spray operator. As a rule, at lower spray outputs and thinner layers, there is less rebound and hence improved performance. The spray mortar must be applied perpendicular to the substrate or to the concrete base. This gives optimal adhesion and compaction and minimises spray rebound. The mortar is applied evenly with a sweeping, circular motion, by hand or mechanically. Spraying reinforcement is particularly challenging and needs an experienced operator, since cavities caused by spray shadow are very common. The space behind the reinforcement must first be filled. The optimum spraying distance is from about 0.4 to 1.0 metre. If the spraying distance is greater than that, spray rebound and dust production are increased and overall efficiency is reduced.

10.23. Processing times

Processing time for the individual mortars is available from the technical data sheets. Note that ambient temperatures and relative humidity of the ambient air affect processing times and must therefore be taken into account.
Immediately on completion of coating, and during and after the coating's hardening stage, the surface is checked for cavities, cracks or damp spots.

Wet spraying in a tank

Wet spraying in a sewer

10.24. Mortar coating after-treatment

It is essential to protect the completed coating from drying out too quickly. Shaft covers must be lined with plastic sheeting and kept closed for at least 7 days to exclude draughts. For rainwater and mixed water systems, covers must be lined and kept closed until the system is returned to service and for a minimum of 28 days. Relative humidity should be > 95%. Since shaft covers can often not be closed early on because of work going on around the edge and the fresh coating is directly exposed to sunlight and draughts, it is helpful to use an after-treatment agent (HERMES TECHNOLOGIE's after-treatment agent D615.)

After-treatment spraying

After-treatment spraying

10.24.1. After-treatment for coated structures

Depending on the type of structure, its condition and size, it is advisable to continually remoisten for a period of at least 7 days. Surfaces are either covered with wet cloths or sheeting and then plastic sheeting to protect these from drying out; or saturated by spraying using a water sprinkling system in cycles of 15 mins per 24 hours. ERGELIT products can be quickly exposed to water load (see technical data sheet).

Sprinkling with water

Sprinkling with water

Covering with plastic sheeting

Site ventilation systems must not be used after coating has been applied. To prevent draughts in newly coated sewers, the ends of the sections that have been treated must be sealed across with plastic sheeting.

Even in sewers or drains which will be taking a water load after coating and hence have high air humidity (which should be measured and recorded), the headspace must have follow-up humidification, if a through draught cannot be prevented by closing the inspection cover and lining it with plastic sheeting. The dew point should be checked. Humidification lower than the dew point is helpful. The same holds true for inspection shafts.

Sealing sewer with plastic sheeting

10.25. Water retaining measures

- Very high air humidity > 95%
- Laying on water retaining coverings (e.g. wet jute, possibly in combination with plastic sheeting).
- Post-treatment film (e.g wax-based)

10.26. Humidification measures

- continuous spraying of coated surfaces, or flooding them with water

11. Quality assurance

11.1. Measuring consistency of fresh mortar

Measuring flow spread

To check the consistency and hence the W/S ratio, an appropriate amount of fresh mortar is taken from the flowing mix. The mortar should be taken 5 minutes after mortar mixing has begun.
After 15 strokes on the Hägermann flow-table, the spread is measured across the sample and recorded.
For comparison, consistency is also measured at the end of the distance pumped, i.e. beyond the spray nozzle.

11.2. Checking the strength of the spray mortar

During operations at least one box should be filled with the spraying mortar. A 30 x 30 x 4 cm box is sprayed full of mortar while work is in progress. Where large grain mortar (KT40 or KS2bL) are used, one short side can be removed and the box raised off the ground so that the test sample is not affected by loose grains. After 24-48 hours the mortar is removed from the mould and 3 prisms 4 x 4 x 16 cm are cut from it. The mortar is then stored under water for 27 days. On the 28th day, tensile bending strength and compressive strength must be tested in a laboratory. HERMES Technologie can carry out this test.

11.3. Testing adhesive tensile strength

Adhesive tensile strength is used as the measure of the coating's adhesion to the concrete surface. The test is carried out in a similar way to the test procedure for measuring surface tensile strength. The number of tests to measure adhesive tensile strength will be decided by the client in the light of constructional conditions.

Adhesive strength test die

Adhesive strength test die

The guide values to be respected for bond tensile strength are the values given in DWA-M 143-17.

The pull-off point should be recorded photographically.
The mortar will have passed the test if pull-off takes place within the substrate. If there is any doubt, further tests should be carried out. A wet substrate or water in the radial groove reduces bond strength. Coating thickness above 15 mm has a negative effect on the test. From 20 mm coating thickness the procedure cannot be used with circular dies. In that case, square cuts must be made into the substrate in the test area using a diamond cutting disc and the test must be carried out using square dies.

	For pipes and shafts of up to 1.5 m (irrespective of substrate)			**In all other cases**		
	Thickness of mortar layer to applied (mm)			Concrete	Brickwork	
	< 15	15 – 40	> 40			
	Mean value 1)	Mean value 1)		Mean value 1)	Mean value 1)	Smallest individual value
Surface tensile Strength [MPa]	Surface Same as "In all other cases"	> 0.5	n/a	> 1.0	> 0.5	≥ 0.3
Reboundhammer	20 N/mm²	15 N/mm²	n/a	20 N/mm²	20 N/mm²	15 N/mm²

1) Mean value from at least 3 individual readings.
These values apply only to the substrate. These values must not be assumed to apply to coatings. For coating thicknesses > 15 mm, a bond strength test does not deliver reliable values.
Surface tensile strength is tested in relation to the coating's bond strength as per DIN EN 1542. The number of tests must be specified by the planner in the light of structural conditions. Alternatively, if surface tensile strength cannot be tested, a non-destructive Schmidt hammer test of compressive strength should be carried out and values recorded.

11.4. Testing coating thickness

Testing the actual thickness of the new coating is carried out with a depth gauge or a nail marked off with target depths. Testing the coating thickness as it sets is only possible destructively. Thickness can be measured by drilling with a drill and a 25 mm (approx) drill bit. The layer to be tested is measured with a depth gauge.

12. Health & safety precautions

The present manual describes operations for wet spray coating sections of wastewater building structures, wastewater pipes and installations, using WW mineral mortars. In principle, these operations take place in confined spaces within wastewater constructions. They present high potential risk, and are therefore classified as ‘dangerous operations’ according to Confined Space Regulations 1997. Dangerous operations are those where the working process, the type of activity, the materials used or the working environment presents a high level of hazard because adequate safety measures cannot be taken. In order to protect the operator from these factors the following rules should be observed. They make no claim to be exhaustive, and are offered without guarantee. In accordance with CSR 1997, employees are to be given health and safety training and instructed in the dangers related to their work and the measures to take to avoid these. This training should be recorded. The following laws, regulations and guidelines shall be noted and complied with:

- Health and safety at work legislation
- Workplace regulations
- Building site regulations
- Industrial safety regulations

The relevant work-place safety regulations are set out in DWA M 143-17. Attention should be paid to EU safety data sheets relating to the materials, which should be available on site. Operating instructions are to be provided.

13. Disposal of waste

Hard ERGELIT mortar must be disposed of as building site waste. A REPA sack disposal system is available for disposing of ERGELIT bags.

14. Operator qualifications

The technical staff employed are instructed by experienced colleagues. Every employee has to undergo training in handling ERGELIT mortars. At least one employee will have completed an SIVV course (vocational training course in concrete).

15. Warning notices and safety instructions

All information and instructions are given in order to avoid material damage or malfunctions and to protect personnel. It is the duty of the site manager to ensure that all persons engaged in activities on site are instructed in the relative dangers and in how to avoid them. Danger to personnel and property must be reduced to a minimum. Materials are only to be used for their intended purpose.

15.1. Warning notices

Danger

Danger:
This symbol indicates an immediate threat to life and health. Failure to heed this warning may seriously affect health and even lead to life threatening injuries.

Warning:
This symbol indicates a potentially dangerous situation. Failure to heed this warning may result in slight injury or damage to property.

Note:
This symbol indicates an important notice regarding the correct way to handle equipment. Failure to observe this instruction can lead to malfunctions.

Personal safety equipment

During servicing, maintenance, diagnostic inspection/ fault rectification/ repair and cleaning operations, it is essential that staff wear personal protective equipment. It is the site manager's responsibility to ensure that anyone working on the site has the necessary personal protective equipment available and is wearing it during operations.

Wear protective goggles!
Liquids expelled under pressure can damage your eyes.

Wear gloves!
Sharp edges can cause injury to hands.

Beware high voltage!
Isolate equipment from electrical supply before installing, servicing or repairing

Protective clothing
For protection from extreme weather conditions such as temperature, wind, rain, snow etc

Safety footwear
For protection from heavy falling objects and slipping on non anti-slip surface

Ear protectors
For protection from damage to hearing

Respiratory protection
To protect against the harmful effects of dust and similar materials and agents.

Respiratory protection
Where there is aerosol formation in sewage water area

15.2. Operating instructions

As per § 20 GefStoffV

Operating instructions

Date: 20.08.2020
Editor: Gabriele Regente

Area of work/activity: Hermes Technologie GmbH & Co. KG, Schwerte

Hazardous material declaration

ERGELIT-Trockenmörtel

Risks to humans and the environment

- Irritates skin and mucous membranes
- Risk of serious damage to eyes
- Prolonged contact with this product, once mixed with water, can cause serious injury to skin. These effects can be exacerbated where skin is already damaged.
- Water hazard class 1
- Only arises when there is accidental spillage of large quantities of fresh mortar leading to increased pH level
- This product is chromate-reduced

Safety measures, rules of conduct, hygiene measures

- Keep out of the reach of children
- Do not breathe dust. When processing, do not kneel in fresh mortar and avoid contact with skin
- Avoid contact with eyes or skin.
- On contact with eyes, immediately rinse thoroughly with water and consult a doctor
- Wear appropriate gloves
- Wear P1-P3 dust mask (where dust develops)
- Eyes: Wear protective goggles with Type XZZ 3 or 4 safety lenses
- Hands: Wear nitrile-impregnated cotton gloves with the CE label
- When mixing mortar with water, do not eat, drink or smoke. Wash hands before breaks and at end of

Actions in the event of an emergency

- Fire-fighting measures: All extinguishing agents are suitable. Only the packaging is flammable. Contents harden on contact with water.
- Environmental protection measures: Avoid discharge into drains and ditches
- When cleaning up/ collecting up: Pick up using equipment
- Additional information: Hardens quickly after contact with water - can then be disposed of as

Firebrigade
Tel.: 112

First Aid

- If breathed in, move to fresh air. If symptoms persist, consult a doctor.
- On contact with skin, wash off immediately with plenty of water – Remove heavily soiled clothing
- On contact with eyes, immediately rinse thoroughly and consult a doctor without delay
- If swallowed, rinse mouth and sip plenty of water without inducing vomiting. If symptoms persist, consult a doctor

Emergency services
Tel.: 112

Handling, correct disposal

- Directions for disposal: Once in contact with water, dispose of as concrete
- EWC n°.: 17 01 01 Concrete
- Transport indications: Non-hazardous material in terms of transport regulations
- Packaging: Can be recycled under the REPASACK system

16. Risk assessment

Description of working steps and risk		Reference number
Coating inspection shafts		
Job site		Date of report
Assessed by	Assessment date	**Nº of this version**
Signature:		

Comparative risk rating = risk x probability					
	1	**2**	**3**	**4**	**5**
Probability	Very unlikely	Unlikely	Likely	Very likely	Certain to occur
Risk	slight injury	moderate injury	reportable injury	quite severe injury	life threate-ning/ fatal injury

Relative degrees of danger				
1 to 5 insignificant	6 to 10 low	11 to 15 moderate	16 to 20 high	21 to 25 extreme

16.1. Where are the hazards/ potential hazards?

Great care must be taken with hazards that can cause serious injury, including to other workers and visitors. It may be important, even necessary, to enlist the collaboration of safety advisers or their representatives, since they can assess dangers that may appear to

be unimportant or even non-existent.

Decide who may be injured and how

It is important to bear in mind people who are not directly involved in or on the site, or only occasionally, or who are present after normal working hours, such as cleaning staff, subcontractors etc. Special consideration should be given to pregnant women and to trainees entering the danger area.

Assess the risks and decide whether the existing safety arrangements are adequate or must be improved.

Every hazard identified must be assessed as to whether and to what extent it can lead to injury, or whether adequate measures can/must be taken to minimise the risk. In terms of risk control, the following hierarchy should be observed, recorded and implemented in order to bring about the best possible and most effective risk-aware practice.

- Eliminate the hazard
- Reduce hazared by using other methods
- Isolate the hazard with barriers and/ or blocking access completely
- Label the hazard
- Personal protective equipment is a simple safety measure
- Effective protection comes from disciplined staff observing control procedures

Recording results of risk assessments

Firms with 5 or more employees must keep a written record of the assessment, the risks and the steps put in place to minimise risk, inform employees of the results and give appropriate training.

Risk assessments must be continuously revised and if necessary adapted

Risk assessments must be checked at regular intervals for feasibility and improvement. Parameters, equipment and operating techniques are emended as necessary. New materials, machinery or techniques must be checked for compatibility with existing risk assessments and adapted as necessary.

A standard risk assessment form is an important, continuously flexible basis for safe, accident-free operations. This is required by law under Confined Spaces regulations 1997.

Code of practice “Working in enclosed spaces of wastewater systems”

16.2. Presence of toxic/explosive gases, oxygen rich/poor environments

Identified hazard 1	Presence of toxic/ explosive gases, oxygen rich/poor environment					
Degree of risk	**High**					
Persons at risk	Employees	**X**	General public	**O**	Site personnel	**X**
Controls						
1. After shaft is opened, ventilate for 10 minutes, followed by a 10 minute gas measurement by trained specialist staff, starting at the bottom of the shaft						
2. Each operator working in the shaft is equipped with a harness and hard-hat and is then secured by safety line to a steady anchor point (tripod). The atmosphere in the shaft is continuously monitored with a gas monitor. Operators working on the open shaft are provided with standard working clothing.						
3. Gas monitors are serviced and recalibrated once a year by the manufacturer. Before beginning work, operators test battery voltage as well as the equipment's alarm function. Defective equipment is not used, but is sent immediately for repair.						
4. Smoking, fire, naked lights, eating and drinking are not allowed within a 5 metre radius.						

Special areas of risk and risk rating (mandatory part of every safety check)	**Hazard**	**Probability**	**Risk rating**	**Further measures required**
Explosion and fire	5	1	5	No
Gassing and asphyxiation	5	1	5	No

Over-all risk rating with existing controls in place	**Low**

16.3. Risk to operators and equipment of falling into open shafts

Identified hazard 2	Risk of persons or equipment falling into open shaft					
Level of risk	**High**					
Persons at risk	Operators	**X**	General public	**O**	Site personnel	**X**

Controls
1. Barriers are erected to prevent access to open shaft during interruptions to operations, to prevent falling
2. Operators are protected by wearing hard-hats and harnesses tied off to a secure point
3. Employees not involved in operations are not allowed in the risk area
4. Tidiness and cleanliness are obligatory and help to obviate tripping hazards
5. Operators and other persons in the work area have received safety instruction and are properly equipped
6. The manhole cover is immediately replaced if work is interrupted or ended, or a safety barrier is erected.

Special areas of risk and risk rating (mandatory part of every safety check)	**Hazard**	**Probability**	**Risk rating**	**Further measures required**
Injury from falling	5	1	5	No

Overall risk rating with existing controls in place	**Low**

16.4. Manual work and repetitive actions / movements (RSI syndrome)

Identified hazard 3	Manual handling and repetitive actions/ movements (RSI syndrome)					
Level of risk	**Hoch**					
Persons at risk	Operators	**X**	General public	**O**	Site personnel	**O**
Controls						
1. Manhole covers are only lifted with appropriate lifters, if necessary by 2 operators						
2. All other operations are automated and remotely controlled						
3. Employees receive instruction and training in safe lifting techniques						

Special areas of risk and risk assessment (mandatory part of every safety check)	**Hazard**	**Probability**	**Risk rating**	**Further measures required**
Injury to muscles, joints and skeleton	4	1	4	No
Crush injuries	4	1	4	No

Overall risk rating with existing controls in place	**Low**

16.5. Effects of wastewater/ chemicals, development of typical pathological conditions

Identified Hazard 5	Effects of exposure to wastewater/ chemicals, development of typical pathological conditions					
Level of risk	**High**					
Persons at risk	Operators	**X**	General public	**O**	Site personnel	**X**

Controls

1. Operators receive information and training about the risk of infection when carrying out work in wastewater areas, staff are given continuous instruction on hygiene measures
2. Operators are equipped with the appropriate personal safety equipment
3. Materials for washing, cleaning and disinfecting, as well as bottles of eyewash, are kept in each vehicle
4. Complete first aid equipment is kept in each vehicle as per occupational health guidelines
5. Every wound or graze is immediately disinfected and covered, and may be referred to doctor/ hospital
6. All employees receive the appropriate immunisation protection, hepatitis A & B, tetanus and their immunisation record is kept up to date
7. All employees receive a regular occupational health check

Special areas of risk and risk assessment (mandatory part of every safety check)	**Hazard**	**Probability**	**Risk rating**	**Further measures required**
Poisoning, infections and chemical effects e.g. burns, nausea, irritation	5	1	5	No

Overall risk rating with existing controls in place	**Low**

16.6. Exposure to chemicals

Identified hazard 6	Exposure to chemicals					
Level of risk	**High**					
Persons at risk	Operators	**X**	General public	**O**	Site personnel	**X**

Controls

1. Operators receive information and training about the risk of infection when carrying out work in wastewater areas, staff are given continuous instruction on hygiene measures
2. Operators are equipped with the appropriate personal safety equipment
3. Materials for washing, cleaning and disinfecting, as well as bottles of eyewash, are kept topped up in each vehicle
4. Complete first aid equipment is kept in each vehicle, as per occupational health guidelines
5. Every wound or graze is immediately disinfected and covered, and may be referred to doctor/hospital
6. All employees receive the appropriate immunisation protection, hepatitis A & B, tetanus and their immunisation record is kept up to date.
7. All employees receive a regular occupational health check.

Special areas of risk and risk rating (mandatory part of every safety check)	**Hazard**	**Probability**	**Risk rating**	**Further measures required**
Infections and/or illnesses	5	1	5	No
Poisoning, infections and burns, nausea and irritation caused by chemicals	5	1	5	No

Over-all risk rating with existing controls in place	**Low**

» **Company doctor / own doctor:**
Name: _____ Address: _____ Tel.: _____

» **Company fire service /public fire service**
Name: _____ Address: _____ Tel.: _____

» **Hospital:**
Name: _____ Address: _____ Tel.: _____

16.7. Working in bad weather conditions

Identified hazard 7	Working in bad weather conditions					
Level of risk	**High**					
Persons at risk	Operators	**X**	General public	**X**	Site personnel	**X**

Controls

1. Operators make an assessment of weather-associated risks immediately before beginning work
2. If the weather conditions during operations deteriorate (storm, heavy rain, frost, snow etc) so that risks arise for the operators, work is immediately stopped. When there is ice and snow or when working below 0ºC, de-icing salt and grit is made available and is applied.
3. All operators are issued with weatherproof work clothing and waterproof jackets.

Special areas of risk and risk rating (mandatory part of every safety check)	**Hazard**	**Probability**	**Risk rating**	**Further measures required**
Drowning	5	1	5	No
Injury from objects falling or being blown around	5	1	5	No
Falling	5	1	5	No

Over-all risk rating with existing controls in place	**Low**

16.8. Environmental pollution of watercourses, drainage systems and sewage treatment plants

Identified hazard 8	Environmental pollution of watercourses, drainage systems and sewage treatment plants					
Level of risk	**High**					
Persons at risk	Operators	**X**	General public	**X**	Site personnel	**X**
Controls						
1. Care must be taken that no material residues of any sort or other substances (cleaning materials) get into the drainage system, watercourses, run-off or into the neighbouring environment (ground). For this, it is essential to use plugs, plastic sheeting and binding agents.						
2. Operators receive information and continuous training about procedures in case of leakages.						
3. Operators will keep the client, the client's environmental protection agent and his own management fully informed about any damage to the environment						
4. All residual materials that accumulate (solid or liquid) are disposed as per regulation and only by certified waste disposal contractors, with written documentation						
5. All transport of waste materials will be undertaken only by certified transport contractors						

Special areas of risk and risk rating (mandatory part of every safety check) **Environmental risk 1= no risk 5 = catastrophic damage**	**Hazard**	**Probability**	**Risk rating**	**Further measures required**
1. Fouling surface watercourses	3	2	6	No
2. Risk of odour or biological risk to population	2	2	4	No

Over-all risk rating with existing controls in place	**Low**

16.9. Fuel consumption and vehicle use

Identified hazard 9	Fuel consumption and vehicle use					
Level of risk	**High**					
Persons at risk	Operators	**X**	General public	**X**	Site personnel	**X**
Controls						
1. Driver training with emphasis on safety, fuel conservation and ecology						
2. Itinerary planned daily in order to reduce unnecessary mileage						
3. Company vehicles are inspected and serviced at the prescribed intervals in order to preserve their efficiency						
4. All new vehicles purchased will be exclusively fuel-efficient models (EURO 4-5)						

Special areas of risk and risk rating (mandatory part of every safety check) **Environmental risk 1= no risk 5 = catastrophic damage**	**Hazard**	**Probability**	**Risk rating**	**Further measures required**
Fuel consumption	4	2	8	N
Emissions	4	2	8	N

Over-all risk rating with existing controls in place	**Low**

17. Model tender specification

High-pressure water cleaning
with high-pressure water blasting equipment back to sound, stable substrate, operating pressure 400 bar, water consumption >24 litres/min. Distance between rotary nozzles and wall < 20 cm, blasting angle 90º, surfaces to be blasted in accordance with safety regulations. These specifications are only general indications of good practice for obtaining the following substrate surface conditions. Other techniques may be necessary.

Surface condition after blasting, as per DWA-M 143-17, shall

- be free from sewer film, oils, fats, paraffins, chlorides, sulphates and other substances and layers that interfere with adhesion
- be free from loose or detached material
- have substrate surface roughness of between 1 mm and 2 mm
- in the case of concrete, have aggregate near the surface that is clearly exposed
- have strength as set out in DWA-M 143-17
- have any steel or cast iron blasted to Sa2 or Sa2½ degree of cleanliness, the cost being calculated by m^2

Wet spray coating
As per DIN EN 15885 and DWA-M 143-17
Produce fresh mortar in a powered mixer using quantity of water as laid down in technical data sheet.
Mortar is then pumped to spray nozzle via a piston or spiral pump. Air is introduced at the nozzle. Minimum air pressure at nozzle is > 3 bar for volumes of air > 1,000 litres/min. Nozzle is set at 20 - 50 cm from the surface to be coated. Final surface condition shall be spray-rough. Minimum coating layer is 1.55 x depth of water penetration, but at least 8 mm.

DN _____ Length_____m

Where coating thickness differs from minimum coating thiockness e.g. because of heavy corrosion or on the basis of static calculations:
Thickness selected: _____mm

Material as per DIN 19573:
WW- XWW3 coating mortar
Material:ERGELIT-KS1
Indication of quantity in m²

18. Further types of WW mortars

WW masonry mortars meeting DIN 19573 - XWW3
ERGELIT-KT 10
ERGELIT-KT 40
ERGELIT-SBM
ERGELIT-KS 1

WW jointing mortars meeting DIN 19573 - XWW3
ERGELIT-KS 1
ERGELIT-KS 2
ERGELIT-KBi

WW jointing mortars meeting DIN 19573 – XWW4
ERGELIT-KS 2 Certified, but we recommend
ERGELIT-KS2bL where there is BSC
ERGELIT-KS 2b L

WW coating mortars meeting DIN 19573 - B2 - XWW3
ERGELIT-KS 1 has DIBt approval certificate Nº. Z-53.5-461
ERGELIT-KS 2
ERGELIT-KT 40

WW coating mortars meeting DIN 19573 - B2 – XWW4
ERGELIT-KS 2 Certified, but we recommend
ERGELIT-KS2bL where there is BSC

WW coating mortar meeting DIN 19573 – B1 - XWW3
ERGELIT-KT 10

WW tile-laying mortar meeting DIN 19573
ERGELIT-KS 1
ERGELIT-KSP

WW injection mortars for repair/ renovation of branch connections
ERGELIT-Kanaltec cF
ERGELIT-Kanaltec iS

WW Injection mortar for filling cracks, non-flexible joints and cavities, and for soil stabilisation, in accordance with DIBt-approval certificate nº Z-53.5-461
ERGELIT-KBi

WW repair mortars meeting DIN 19573 - B2 - XWW3
ERGELIT-KS 1
ERGELIT-KS 2
ERGELIT-KT 10
ERGELIT-KT 40
ERGELIT-SBM

WW repair mortars meeting DIN 19573 - B1
ERGELIT-10 SD
ERGELIT-10S special

WW shafthead mortars meeting DIN 19573 - XWW3
ERGELIT-SBM plastic
ERGELIT-superfix 35F flowable

WW grouting mortars
ERGELIT-fix35 F
ERGELIT-V35

19. References

HERMES technical data sheets in accordance with DIN 19573
ERGELIT performance data
ERGELIT declarations of performance in accordance with DIN EN 1504
Manual coating quality assurance handbook 7th edition
DIN 19573
DIN EN 15885
DWA-M 143-17
DWA-M 211
DWA-M 143-8
DWA-M 168

RiLi-SiB
SIVV. Training course materials, GFW-Bau
ZTV-Ing Training course materials for German drainage systems certificate, Rainer Hermes
ZKS Training course materials: coating, Rainer Hermes

Other WW mortars

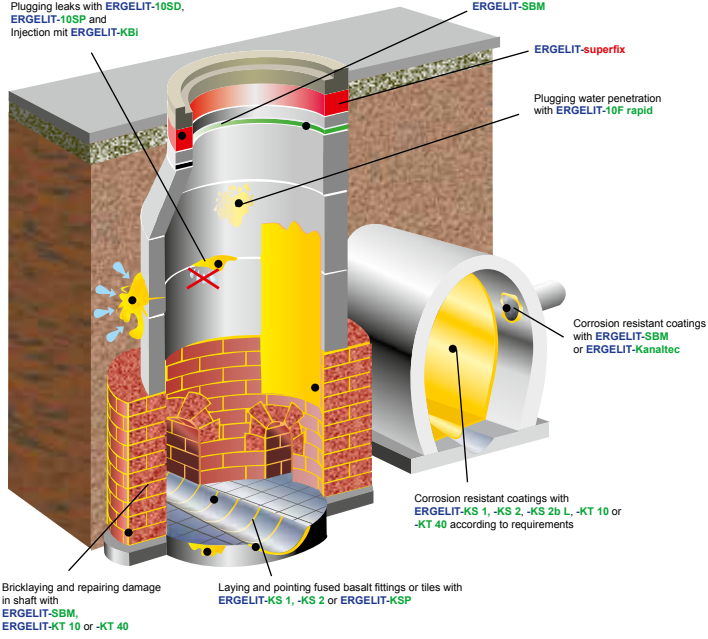
- **ERGELIT-superfix 10**
  Early high strength free-flowing assembly mortar for gaps from 1mm
- **ERGELIT-superfix 35**
  Early high strength free-flowing assembly mortar for gaps from 10mm
- **ERGELIT-rapid 10**
  Early high strength free-flowing assembly mortar for gaps from 1mm

- **ERGELIT rapid 40**
  Early high strength free-flowing assembly mortar for gaps from 10mm
- **ERGELIT-fix 10 or fix 35, fix 35F and fix 80**
  Early high strength free-flowing assembly mortar
- **ERGELIT-V10 oder V35 oder V80**
  High strength grout, also for grouting invert tiles and pre-cast shaft sections.
- **ERGELIT-S100**
  For under-packing manhole frames and prefabricated sections
- **ERGELIT-FB35 fix**
  For grouting and packing between manhole frame and carriageway
- **ERGELIT-10S special**
  For sealing leaks and accelerating other mortars
- **ERGELIT-10F rapid**
  The 10 second mortar for plugging infiltration
- **ERGELIT-10 SD**
  Kneadable mortar for plugging leaks
- **ERGELIT-KS 1, KS 2, KS 2b L**
  For bricklaying, pointing, laying tiles, coating, spraying: early strength high corrosion protection
- **ERGELIT-KBi**
  Injection mortar for filling cavities, gaps and holes
- **ERGELIT-DS**
  Sealing slurry mainly for sealing surfaces
- **ERGELIT-SBM**
  For masonry work in drainage systems and inspection shafts
- **ERGELIT-KSP**
  Adhesive for use in drains, especially recommended for large ceramic tiles
- **ERGELIT-FM flex**
  For pointing joints

» **ERGELIT-iV**
When injecting the annular space around rigidly anchored plastics liners (wound and studded tubes)

» **iCem03**
When injecting the annular space around rigidly anchored plastics liners (wound tubes for low hydration heat)

Examples of the use of ERGELIT in drainage system rehabilitation



ERGELIT-KS 1 = municipal.wastewater
ERGELIT-KS 2 = industrial wastewater
ERGELIT-KS 2b L = biogenic sulphuric acid corrosion

Layout: advertising21.de

DEUTSCHLAND
HERMES Technologie GmbH & Co KG

Bürenbrucher Weg 1a
58239 Schwerte

Tel: +49 23 04 97 123 0
Fax: +49 23 04 7 46 80

office@hermes-technologie.de
www.hermes-technologie.de

ÖSTERREICH
HERMES Technologie GmbH

Gewerbepark Ost 7
A-4846 Redlham

Tel: +43 76 73 23 200
Fax: +43 76 73 23 203

info@hermes-technologie.at
www.hermes-technologie.at

FRANCE
HERMES Technologie SARL

ZAC de Royallieu 17
Rue du Four St-Jacques
F-60200 Compiègne

Tél: +33 / 344 970 222
Fax: +33 / 344 970 932

bureau@hermes-technologie.com
www.hermes-technologie.fr

ENGLAND
HERMES Technologie Ltd.

Hastings,TN34 1PD, East Sussex
Branch:
88 Roe Lane, Southport
PR9 7HT, Merseyside

Phone: +44 790 89 62 521

office@hermes-technologie.com
www.hermes-technologie.com

ČESKÁ REPUBLIKA
HERMES TECHNOLOGIE s.r.o.

Na Groši 1344/5a
CZ - 102 00 Praha 10

Tel: +420 271 750 685
Fax: +420 271 751 346

hermes@hermes-technologie.cz
www.hermes-technologie.cz

POLEN
HERMES Technologie Sp. z o.o.

Grabarska 1
PL -50-079 Wrocław

Tel.: +48 516 456 242

office@hermes-technologie.pl
www.hermes-technologie.pl

Visit us on Facebook:
www.facebook.com/hermes.technologie.de

ERGELIT

www.hermes-technologie.com