Federal Ministry for Digital and Transport

Additional technical terms of contract and guidelines for Civil Engineering Works

ZTV-ING

Part 4
Steel Construction, Composite Steel Construction

Section 5
Corrosion Protection of Bridge Ropes

Notified in accordance with Directive (EU) 2015/1535 of the European Parliament and of the Council of 9 September 2015 laying down a procedure for the provision of information in the field of technical regulations and of rules on Information Society services (OJ 241 of 17 September 2015, p. 1).

Last updated: 2024/08

Content Page

1 General information

1.1 Scope

(1) Section 5 of Part 4 applies only in conjunction with Section 3, Section 4 and Part 1 General.

(2) This section applies to the corrosion protection of ropes and cables in new and existing structures. It also applies to the corrosion protection of additional construction parts, such as cable couplings and saddles.

(3) The construction must be carried out in accordance with DIN EN ISO 12944-3 in order to protect against corrosion.

1.2 Definitions

(1) Section 4(1.2) applies.

(2) **Anti-corrosion tapes**

Tapes for the winding process which, through cold welding of the material, create dense and robust corrosion and UV protection on the rope surface, consisting, for instance, of butyl rubber.

(3) **Press connector**
Connector for sealing the transition between the free length and anchorage.

(4) **Sheath**

Factory-extruded external corrosion protection (e.g. High Density Polyethylene (HDPE)).

(5) **Winding process**

Method for external corrosion protection of bridge ropes by wrapping with anti-corrosion tapes with the help of winding robots or by hand. It can also be used as UV protection on pre-damaged surfaces (e.g. coatings or PE piping).

1.3 Requirements

(1) The corrosion protection of ropes and cables must be designed for corrosion category C5 in accordance with DIN EN ISO 9223. In the case of anchorage structures inside the superstructure or pylons, where the penetration of corrosive substances can be excluded, corrosivity category C4 shall be used.

(2) In the area above and below the road surface, splash water, spray mist and the impact of chipping must be taken into account.

(3) For non-renewable corrosion protection components or inaccessible components, the protection duration must be at least equal to the service life of the bridge. For renewable components, the protection duration must be at least 25 years.

(4) The rules for testing and maintenance shall be included in the test manual referred to in Section 4.

(5) During the construction period, unprotected components (such as ungalvanised threads, connectors between free length and anchorage, connections of dampers and rope clamps) must be temporarily protected against corrosion.

1.4 Protection systems for anchorages and non-load-bearing components

(1) The anchorages and all non-load-bearing components, e.g. caps, must be protected by a thermally sprayed zinc coating in accordance with DIN EN ISO 2063 with a target layer thickness of 100 µm or by hot-dip galvanising in accordance with DIN EN ISO 1461. The threads of the anchorages are not galvanised.

(2) The anchorage's galvanised surfaces also receive a multi-layer coating with a target layer thickness of 240 µm. For non-load-bearing components, a nominal coating thickness of 160 m or an equivalent corrosion protection is sufficient.

(3) The threads must be protected against weathering with temperature-resistant acid-free greases or equivalent systems.

1.5 Corrosion protection plan and execution instructions

(1) The corrosion protection work on ropes and cables shall be based on the corrosion protection plan and the execution instructions. These documents shall be drawn up by the Contractor in consultation with the implementation plan and shall be included in the testing and approval procedure referred to in Section 2 of Part 1.

(2) The corrosion protection plan consists of overview drawings and detailed drawings, e.g. for measures on ropes, sealing sleeves, anchorage structures.

(3) The instructions must describe how and in what order the corrosion protection work on the individual components and rope areas is to be carried out.

(4) During execution,

— the corrosion protection plan and

— execution instructions

must be kept on site and observed.

(5) The corrosion protection plan and the execution instructions are part of the existing documentation.

1.6 Documentation

(1) The corrosion protection measures must be documented in consultation with the client in accordance

with Section 3. The documentation must be handed over to the client.

(2) The essential characteristics of the corrosion protection system, the performance of the corrosion protection and the application conditions shall be documented in accordance with the forms set out in Annex A.

2 Fully Locked Spiral Ropes

2.1 General information

2.1.1 Materials

(1) All materials used must be repairable and machinable.

(2) All substances and materials used must be compatible with each other. Their adhesion and deformability must not be impaired.

2.1.2 Surface preparation

(1) Bandings used as transport and assembly safeguards must be removed before surface preparation.

(2) To remove local oily and greasy residues, the use of a cloth moistened with organic, halogen-free solvents is permitted. No detergents should penetrate the rope.

(3) The ropes must be freed from any leaked rope filler. The rope filler does not need to be completely removed from the gussets between the rope wires.

(4) Sufficient compatibility must be demonstrated between the rope filler and the subsequent external corrosion protection, see Technical Delivery Conditions for Coatings, Sealants and Injectors for Corrosion Protection of Fully Locked Spiral Ropes (TL KOR-VVS) and Technical Test Specifications for Coatings, Sealants and Injectors for Corrosion Protection of Fully Locked Spiral Ropes (TP-KOR-VVS).

2.2 Coating systems

2.2.1 General information

(1) Unless otherwise specified below, the requirements of Section 3 apply.

(2) All coating materials used, as well as the resulting coating system, must comply with the TL-KOR-VVS.

2.2.2 Surface preparation

(1) Foreign impurities (oils, grease, salts, etc.) must be removed with suitable cleaning agents.

(2) Surfaces with metallic coatings must be prepared by sweep blasting (DIN EN ISO 12944-4). An enclosure must be provided. A maximum of 15 µm of the metallic coating may be removed.

2.2.3 Layer thicknesses

(1) The coating system must consist of at least three layers. The target layer thickness of the overall system shall not be less than 410 µm.

(2) One example of the layer structure of a coating system for fully-locked spiral ropes can be found in Table 4.5.1.

(3) In the spray water and mist area, an additional intermediate coating with a target layer thickness of 150 µm must be applied up to 15 m above and below the road surface.

(4) Coating thickness measurements shall be carried out in accordance with DIN EN ISO 2808.

(5) Double the value of the total target layer thicknesses must not be exceeded.

Table 4.5.1: Example of the layer structure of a coating system for fully-locked spiral ropes outside the spray water and mist area.

	Number of positions	Nominal layer thickness per position
Primer coat	1	50 µm
Intermediate coats	2	150 µm
Top coat	1	60 µm
Overall system without zinc coating	4	410 µm

2.2.4 Execution

(1) The implementation instructions of the substance manufacturer must be complied with.

(2) Surface preparation and application of the primer coat (PC) are carried out on the construction site.

(3) The specifications shall specify whether the PC is to be applied before or after installation.

(4) The PC can be applied before assembly if no damage to the PC is expected during assembly and if it is ensured that subsequent outdoor weathering has no adverse impact on the corrosion protection system (e.g.

by limiting the time until the application of the 1st intermediate coat or by prescribing intermediate cleaning).

(5) The assembly of fully-locked spiral ropes must be carried out in such a way to ensure that damage to the galvanisation and any PC already applied is avoided. *Damage shall be repaired in accordance with Section 3 of Part 4.*

(6) Application of the intermediate and top coat takes place after assembly (including clamping) on the construction site.

(7) Before applying subsequent coatings, each coating layer must be examined for the presence of contaminants of its own and foreign species. Any impurities found must be removed in accordance with Section 3 of Part 4.

(8) Before starting work, depending on the conditions of execution, it must be demonstrated that the type of execution and protective measures will not damage the layers already applied.

(9) Application is done by brush. This is done either by hand or by automated means. In doing so, the execution instructions of the coating material manufacturer must be observed.

(10) The gussets between the individual wires of a rope must also be coated without defects.

(11) Coatings must be protected against damaging influences (e.g. rain, insects, pollen, sand) until the formation of a dust-dry surface (early rain resistance).

2.2.5 Sealants

(1) Sealants shall only be applied to coated surfaces.

(2) After the application of sealants, the sealant surface shall be smoothed. No smoothing agents must be used that could leave a film on the sealant or adversely affect the adhesion on the joint sides.

2.2.6 Control surfaces

(1) In areas of typical stress, control areas must be placed and marked in easily accessible areas up to a height of 15 m above the upper edge of the road surface around the rope.

(2) The number and location of control areas shall be indicated in the invitation to tender. As a rule, control areas are sufficient on two ropes.

2.2.7 Marking

The essential characteristics of the corrosion protection system in accordance with Form A 4.5.1 shall be permanently affixed to the structure in consultation with the client.

2.3 Winding process with anti-corrosion tapes

2.3.1 General information

(1) Winding processes with anti-corrosion tapes may only be used with a proof of use from the building inspectorate, provided that the anti-corrosion tapes do not bear a CE mark in accordance with the EU Building Products Regulation (BPR). In addition, the winding process must be type-approved taking into account the principles of TL-KOR VVS and TP-KOR VVS.

(2) The work instructions on which component type approval is based must be available and must be observed. The work instructions must also include the execution of connections, bumps and repair points.

(3) Points that are not accessible for the winding process (e.g. in anchorage recesses) must be protected otherwise (e.g. coating systems in accordance with 2.2).

2.3.2 Surface preparation

Contaminants from class m3/G5 according to DIN EN ISO 8502-3 and loose components on the rope surface must be removed mechanically with brushes, spatulas or the like before winding, in accordance with the working instructions based on 2.3.1 (2).

2.3.3 Execution

(1) Winding operations shall be carried out in accordance with the instructions referred to in 2.3.1 (2).

(2) Winding operations may only be carried out by personnel who are familiar with the procedure and have received appropriate training from the holder of the procedure.

(3) It must be demonstrated that the applied winding is not damaged by the running gear of mechanical winding devices, magnetic inductive testing devices and the like. The winding must therefore meet at least the indentation resistance requirements of class C in accordance with EN 12068. The residual layer thickness must be at a load of 1 N/mm^2 and 50 °C at least 1 mm after 72 h. The tensile shear strength must be at least 0.05 N/mm^2 at 50 °C in accordance with EN 12068.

2.3.4 Control surfaces

(1) In areas of typical stress, control areas must be placed and marked in easily accessible areas up to a height of 15 m above the upper edge of the road surface around the rope.

(2) The number and location of control areas shall be indicated in the invitation to tender. As a rule, control areas are sufficient on two ropes. In doing so, the provisions of component type approval must be observed.

2.3.5 Marking

The essential characteristics of the corrosion protection system in accordance with Form A 4.5.5 shall be permanently affixed to the structure in consultation with the client.

2.4 Sheath

In progress

2.5 Tests

2.5.1 Monitoring of substances

The contractor must provide the client with an acceptance test certificate 3.2 for all substances before use, in accordance with DIN EN 10204 based on TL KOR-VVS.

2.5.2 Self-monitoring

2.5.2.1 Coating systems

(1) The zinc layer thickness of the rope surface shall be documented in Form A 4.5.2 prior to the coating work.

(2) The execution of the corrosion protection shall be documented in accordance with the corresponding Form A 4.5.3.

(3) The application conditions shall be measured at least twice a day with tested and calibrated equipment. Depending on the climatic conditions, the measurement range must be increased if necessary to ensure that the application conditions are met. Documentation must be carried out in accordance with form A 4.5.4.

(4) After application of each individual layer, the contractor must carry out a layer thickness measurement in accordance with DIN EN ISO 2808. In the case of ropes, three layer thickness measurements are to be carried out per 5 m rope length, distributed across the circumference. The results must be recorded in form A 4.5.2. The test reports are to be submitted to the client.

(5) All automated coating work shall be monitored and subject to camera-assisted recording.

(6) The nature and extent of the camera-assisted recording shall be specified in the tender specifications.

(7) Destructive tests require the client’s consent. Destroyed coatings must be repaired.

2.5.2.2 Winding process

(1) The type and scope of production control must comply with the requirements of the proof of use from the building inspectorate, provided that the corrosion protection tapes do not bear a CE mark in accordance with the EU BPR.

(2) Documentation of the coating thicknesses (e.g. galvanisation) existing before winding is only to be carried out at the cleint's request.

(3) Execution of the corrosion protection shall be documented in accordance with the corresponding Form A 4.5.6.

(4) The application conditions shall be measured at least twice a day with tested and calibrated equipment. Depending on the climatic conditions, the measurement range must be increased if necessary to ensure that the application conditions are met. Documentation must be carried out in accordance with form A 4.5.7.

(5) All automated winding operations carried out must be monitored and subject to camera-assisted recording.

(6) The nature and extent of the camera-assisted recording shall be specified in the tender specifications.

(7) Destructive tests require the client’s consent.

2.5.2.3 Sheath

In progress

2.5.3 Control checks

2.5.3.1 Coating systems

(1) Section 3 shall apply to the nature and scope of the control checks. Destructive tests, such as cross-cut tests, must be avoided.

(2) In the case of control checks on the corrosion protection work, the requirements of Section 3, Annex E (Guidelines for control checks) for personnel and equipment must be met.

2.5.3.2 Winding process

The execution of the winding operations and the documentation must be checked by the building supervisor.

2.5.3.3 Sheath

In progress

3 Stranded ropes

Information on the corrosion protection of stranded ropes is given in section 4 and in the component type approvals.

4 Repair of corrosion protection of fully-locked spiral ropes and cables

4.1 General information

(1) When planning repair measures, the guidelines for the maintenance of civil engineering structures (RI-ERH-ING) must be observed.

(2) The compatibility of the substances for partial renewal or repair with the existing anti-corrosion agents must be taken into account.

(3) In the case of repairs, the documents must be submitted in accordance with point 1.5.

(4) If the corrosion protection of the ropes cannot be tested or renewed, constructive solutions must be developed during planning of the repair work to enable subsequent inspection.

(5) The scope of surface preparation shall be indicated in the tender specifications.

4.2 Coating systems

4.2.1 Protection systems

(1) In the case of fully-locked spiral ropes with hot-dip galvanised outer wire layers, the provisions in point 2.2 shall apply.

(2) In the case of fully-locked spiral ropes with non-galvanised or electrolytically galvanised outer wire layers or of ropes with hot-dip galvanised outer wire layers which have local damage to the galvanisation, an additional primer coat (PC) with a target layer thickness of 50 µm shall be applied. In addition, point 2.2 applies.

(3) An example of the layer structure of a coating system for fully-locked spiral ropes with non-galvanised or electrolytically galvanised outer wire layers or in the case of ropes with hot-dip galvanised outer wire layers can be found in Table 4.5.2.

Table 4.5.2: Example of protection systems for repairs to fully-locked spiral ropes with non-galvanised or electrolytically galvanised outer wire layers or to ropes with hot-dip galvanised outer wire layers

	Number of positions	Nominal layer thickness per position
Primers	2	50 µm
Intermediate coats	2	150 µm
Top coat	1	60 µm
Overall system	5	460 µm

(3) Double the value of the target layer thicknesses must not be exceeded.

4.2.2 Surface preparation

4.2.2.1 General information

(1) To remove old coatings or impurities, only the mechanical processes according to DIN EN ISO 12944-4, as well as washing with warm or hot water with a solvent-free cleaner additive may be used.

(2) If strongly adhesive old coatings or cements/sealants are to be preserved, they must be examined for their functionality. In particular, the adhesiveness and the degree of underfilm corrosion and corrosion creep, for example on thick layers, must be tested in water.

(3) In corroded areas, the coatings and corrosion products must be mechanically removed.

(4) When repairing old injection bodies, it may be necessary to remove damaged areas by cutting.

(5) Broken brush wires must be removed from the surface through post-treatment, e.g. with sandpaper.

(6) In the case of existing coatings, the blast parameters shall be selected in such a way that loose coating components are removed and the parts that adhere to the surface are cleaned and roughened.

4.2.2.2 Galvanised surfaces

(1) To remove rust and corrosion products of zinc coatings, only mechanical surface preparation according to DIN EN ISO

12944-4 should be used. Vapour and wet blasting, as well as pressurised water blasting and flame blasting are not permitted.

(2) Zinc chips resulting from brushing must be removed from the surface through post-treatment, e.g. with sandpaper.

(3) The preparation of coated hot-dip galvanised surfaces must be carried out with the utmost care. The suitability of the blast parameters must be demonstrated on the object in consultation with the client.

(4) In the case of blasting, abrasives are to be used which produce minimal roughening of the surface. The grain size may not be higher than 1 mm. A rounded grain can be used. Ferritic blasting abrasives are not permitted.

(5) Weakly adhesive parts of old coatings on hot-dip galvanised surfaces must be removed by brushing. Where this is not possible, blasting shall be applied in such a way that the zinc coating is largely preserved.

4.2.2.3 Non-galvanised surfaces

If old coatings or cement fixings/sealants are to be completely removed from galvanised surfaces, the surface preparation factor Sa 2½ must be achieved.

4.2.4 Execution of corrosion protection work

(1) *Small-area repairs or improvements are excluded from the enclosure as specified in point 2.2.2.*

(2) Sealed joints must be processed in such a way that a permanent overhaul with new sealants is possible.

4.2.5 Cables

(1) The design of cables for cable-stayed bridges no longer corresponds to the current state of the art and is therefore no longer to be provided for new construction. Cables are generally necessary for the main bearer cables of suspension bridges. However, they are not included in this set of rules.

(2) To repair the corrosion protection of cables, solutions must be developed that are tailored to the individual case. In principle, permanent cable king-pin inclinations should be taken into consideration to improve accessibility to individual ropes for corrosion protection work and for building inspections.

(3) If permanent cable king-pin inclinations are not possible due to static or structural constraints, the cavities in the cables should be injected and the gussets between the cables on the outside of the cable should be sealed. The sealants and injectors specified according to TL- and TP-KOR-VVS are suitable for this purpose.

(4) If cable injection is not possible either or an existing injection is no longer functional, the gussets must not be sealed between the ropes on the cable underside to allow any penetrating moisture the opportunity to escape.

(5) If the surfaces of the individual ropes are accessible for corrosion protection work, the preceding regulations for fully-locked spiral ropes shall apply mutatis mutandis.

(6) After application of each individual layer, a layer thickness measurement must be taken by the contractor. For cables, one measurement per 5 m length shall be carried out on each exposed rope. The results must be recorded in form A 4.5.2. The test reports are to be submitted to the client.

(7) In the case of cables for which corrosion protection renewals or partial renewals are required, it must be verified that accessibility can be improved for later maintenance on the free rope or cable length using appropriate structural measures, e.g. by equipping the structure with appropriate access points, spreading the ropes of a cable to provide accessibility to the single rope, structural improvement of the rope guides, rope deviations and the connections of rope clamps and vibration dampers.

4.3 Winding systems with anti-corrosion tapes

4.3.1 Protection systems

The protection system corresponds to the winding system according to point 2.3.

4.3.2 Planning repair measures

(1) The structural design shall specify whether existing coatings and windings can have windings applied over them.

(2) The repair work shall be carried out in accordance with the working instructions referred to in 2.3.1 (2).

(3) Repair and maintenance measures may only be carried out with materials that correspond to an existing initial winding, if any.

4.3.3 Surface preparation

The same conditions apply as for the initial winding in accordance with 2.3.2.

4.3.4 Execution of corrosion protection work

The same conditions apply as for the initial winding in accordance with 2.3.3.

Form A 4.5.1 Identification of corrosion protection (coating)

Identification of corrosion protection (coating)	**Page**
Building project	**Building number (ASB)**
Construction phase	
Contracting authority	**Name of the construction project**
Contractor	**top**
	bottom
Initial execution: □ Full renewal: □ Partial renewal: □ Repair: □	

Component: (Rope/cable)	**Work cycle how/where: (Surface preparation/primer/intermediate coat/top coat)**	**Material No.**	**Target layer thickness [µm]**	**Workshop = 1 Building site = 2**
	Surface: bare•, hot-dip galvanised • ,			
	galvanised •; ; with old coating •			
	Surface preparation:			
	1. PC			
	2. PC			
	Sealing			
	Injection			
	1. IC			
	2. IC			
	3. IC			
	TC			
	*)			
	*)			

Please tick as applicable

*) *) Free lines for edge protection, adhesive primer, further layers

Form A 4.5.2 Layer thickness report (Coating)

Layer thickness report (coating)	**Page**
Building project	**Building number (ASB)**
Construction phase	
Contracting authority	**Name of the construction project**
Contractor	**top**
	bottom
Inspection body	
Corrosion protection plan No	

- Zinc coating thickness µm
- Primer coat (total) Target layer thickness*) µm

Target layer thickness up to and incl. 1. Intermediate coat

Target layer thickness up to and incl. 2. Intermediate coat

Target layer thickness up to and incl. 3. Intermediate coat (if applicable)

- Overall coating nominal layer thickness*) µm

Measuring instrument (calibration method, reference standard):

Date	**Rope section**	**Layer thickness measurement**			**Comments**
	(linear metre)	**in accordance with No 2.5.2, No 4.2.1 or 4.2.4**			
		1	2	3	

Reviewed:

(Place) (Date)	(Place) (Date)
(Name, signature) For the contractor	(Name, signature) For the client

Please tick as applicable

*) without zinc coating thickness

Form A 4.5.3 Test reports and marking (coating)

Test reports and marking	**Page**
Building project	**Building number (ASB)**
Construction phase	
Contracting authority	**Name of the construction project**
Contractor	**top**
	bottom
Inspector/inspection body	
Initial execution • **Full renewal •** **Partial renewal •** **Repair •**	

Contractor for:

—…….**Surface preparation**: ……

—…….**Coating**:……

—……

Supplier of materials: ……

Corrosion protection plan no: _____

Total surface area _____ **m²**

Control area report for No:…… to..... **and**

number of individual reports in accordance withForm A 4.5.2:.....

and Form A 4.5.3:.....

Comment:

(Place)	**(Date)**	**(Name, signature of inspection body)**

Please tick as applicable

Form A 4.5.4 Test report (coating)

Test report for fully-locked spiral ropes											
											Sheet No:
Date/ Time	**Work process (e.g. surface preparation PC, IC, TC)**	**Procedure (e.g. for surface preparation, application)**	**Weather conditions**	**Temperature [°C] Air/rope**		**Rel. humidity [%]**	**Dew point [°C]**	**Blasting abrasive/ Coating material (Name/ substance No**	**Colour**	**Batch No: (Quality control)**	**Comment (e.g. purity level, particular effects, irregularities)**
For the contractor					**For the client** **Place** **Date** **Name** **Signature**						

	Inspection		Rope section or mountings (linear metre)			

Form A 4.5.5 Corrosion protection marking (winding procedure)

Corrosion protection marking (winding procedure)						**Page**
Building project						**Building number (ASB)**
Construction phase						
Contracting authority						**Name of the construction project**
Contractor						**top**
						bottom
Initial execution □ Full renewal □ Partial renewal □ Repair □						
Component:	**Existing surface:**					
(rope)						
	□ **bare**					
	□ **hot-dip galvanised**					
	□ **Galfan galvanised (Zn95Al5)**					
	□ **galvanised**					
	□ **coated**					
	□ **wound**					
Winding procedure:						
Tape manufacturer:						
Tape:	**Type**	**Colour**	**Thickness**	**Width:**	**Overlapping**	
Basic situation						
Cover situation						
Comment:						

Please tick as applicable

Form A 4.5.6 Test reports and marking (winding procedure)

Corrosion protection marking (winding procedure)	**Page**
Building project	**Works number (ASB)**
Construction phase	
Contracting authority	**Name of the construction project**
Contractor	**top**
	bottom

Initial execution □ Full renewal □ Partial renewal □ Repair □

Component:	**Existing surface:**			
(rope)				
	□ **bare**			
	□ **hot-dip galvanised**			
	□ **Galfan galvanised (Zn95Al5)**			
	□ **galvanised**			
	□ **coated**			
	□ **wound**			
Contractor for:				
- Winding operations:				
- Other work: ……..				
Supplier of materials:				
- Band: ……				
- Miscellaneous: ……				

Corrosion protection plan	No ……				
Overall surface for ropes	No ……	to	No ……		…. m^2
Control area reports	No ……	to	No ……		
Number of individual protocols A 4.5.6: ……					
Comment:					

(Place) **(Date)** **(Name, signature of inspection body)**

Please tick as applicable

Form A 4.5.7 Test report (winding procedure)

Test report (winding procedure)										Sheet No:
Inspection body										
Rope section or mountings (linear metre)	Date/ Time	Working process (e.g. surface preparation)	Weather conditions	Temperature [°C]		Rel. Humidity [%]	Dew point [°C]	Batch No: (Quality control)	Comment (e.g. special features, irregularities)	
				Air	Rope					
1	2	3	4	5	6	7	8	9	10	
For the Contractor Place Date Name, signature									For the Client Place Date Name, signature	