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European Technical Assessment

ETA-24/0184 of 19.04.2024

General part

Technical Assessment Body issuing the European Technical Assessment	Österreichisches Institut für Bautechnik (OIB) Austrian Institute of Construction Engineering
Trade name of the construction product	LMK External Post Tensioning System with 2 to 37 strands
Product family to which the construction product belongs	Post-tensioning kit for external prestressing of structures with strands
Manufacturer	HiSCS S.A. 16, Kifissias Ave. 11526 Athens GREECE
Manufacturing plant	HiSCS S.A. 16, Kifissias Ave. 11526 Athens GREECE
This European Technical Assessment contains	44 pages including Annexes 1 to 21, which form an integral part of this assessment.
This European Technical Assessment is issued in accordance with Regulation (EU) № 305/2011, on the basis of	European Assessment Document (EAD) EAD 160004-00-0301 – Post-Tensioning Kits for Prestressing of Structures.

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Specific parts

1 Technical description of the product

1.1 General

The European Technical Assessment – ETA – applies to a kit, the PT system

LMK External Post Tensioning System with 2 to 37 strands,

comprising the following components, see Annex 1 and Annex 2.

– Tendon

  External tendon with 2 to 37 tensile elements

– Tensile element

  7-wire prestressing steel strand with nominal diameter and maximum characteristic tensile strength as given in Table 1.

Table 1: Tensile elements

Nominal diameter	Nominal cross-sectional area	Maximum characteristic tensile strength
mm	mm^2	MPa
15.7	150	1 860

NOTE 1 MPa = 1 N/mm^2

– Anchorage

  Prestressing steel strand anchored by wedges

  End anchorage, stressing (active) and fixed (passive) anchor with wedges, anchor head, and bearing plate.

– Additional reinforcement in the anchorage zone comprising helix and stirrup reinforcement

– Corrosion protection for tensile elements and anchorages

PT system

1.2 Designation and range of anchorages

1.2.1 General

The anchorage is designated by a three-letter code, followed by one letter indicating the function, by the number of prestressing steel strands, and by the nominal diameter of the prestressing steel strands expressed in mm, i.e. LMK-$_{\text{ABC}}$-$_{\text{DE}}$-M-$_{\text{FG}}$.

Designation for function of the anchorage

LMK-$\boxed{\text{ABC}}$-$_{\text{DE}}$-M-$_{\text{FG}}$ → S for stressing / F for fixed anchorage

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Designation for number of prestressing steel strands

LMK-ABC-DE-M-FG

→ 2 to 37 prestressing steel strands

Designation for nominal diameter of the prestressing steel strand

LMK-ABC-DE-M-FG

→ M-15 for nominal diameter of 15.7 mm

NOTE E.g., LMK-S-7-M-15 designates a stressing anchorage for a tendon with 7 prestressing steel strands and a nominal diameter of the prestressing steel strand of 15.7 mm.

LMK-S is the mechanical stressing anchorage, provided at that end of the tendon where stressing operation takes place. An identical anchorage is placed at the opposite end as fixed anchorage, LMK-F.

The anchorage comprises, see Annex 3

– Anchor head in steel, see Clause 1.12.2

  The prestressing steel strands are individually anchored with wedges in conical holes of the anchor head.

– Bearing plate in cast iron, see Clause 1.12.3

  The bearing plate supports the anchor head and transfers the prestressing force into the structural concrete. The bearing plate provides a centric aperture for passing through the tendon. At the inner end, the sheath is connected to the bearing plate.

– Additional reinforcement, see Clause 1.12.5

  Additional reinforcement of ribbed reinforcing steel comprises helix and stirrups. It confines the structural concrete to facilitate the transfer of the prestressing force.

– Cap, see Clause 1.12.6

  Grouting or protection cap is attached to the anchorage to encase anchor head with wedges and prestressing steel strands. For corrosion protection the cap is completely filled with corrosion protection filling material.

The main dimensions of the anchorages are given in Annex 8, Annex 9, Annex 10, Annex 11, and Annex 12. The anchorages are suitable for 2 to 37 prestressing steel strands with nominal diameter of 15.7 mm and characteristic tensile strength of maximum 1 860 MPa.

For re-stressable and re-placeable tendons, protrusions of the prestressing steel strands are maintained at the stressing anchorage. The extent of the excess length depends on the jack used for re-stressing or releasing. The protruding prestressing steel strands require a permanent corrosion protection and a protection cap.

1.3 Tendon range

The tendon comprises 2 to 37 prestressing steel strands. Nominal cross-sectional area and nominal mass of prestressing steel and characteristic maximum force of tendon are given in Annex 13.

Prestressing and overstressing forces are given in the corresponding standards and regulations in force at the place of use. The maximum prestressing and overstressing forces according to Eurocode 2[1] are listed in Annex 15. In Annex 14 maximum prestressing force and maximum overstressing force of one single prestressing steel strand are given.

[1] Standards and other documents referred to in the European Technical Assessment are listed in Annex 20 and Annex 21.

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1.4 Duct, minimum radius of curvature of tendon

The duct provides an enclosed cavity to contain tensile elements and corrosion protection filling material. Functions of duct are facilitating stressing and filling with corrosion protection filling material, transferring forces from tensile elements to deviator, and taking part in protection of the final tendon.

The duct is assembled of straight tubes in steel or HDPE. Jointing is by welding or mechanical techniques avoiding welding operations on site. Outer diameter and wall thickness of duct and minimum radii of curvature of tendon are given in Annex 5 and Annex 6.

Steel tubes conform to EN 10255, EN 10216-1, EN 10217-1, EN 10219-1, or EN 10305-5.

HDPE tubes conform to EN 12201-1 and EN 12201-2 in PE 80 or PE 100 for pressure ratings of PN 8 or PN 10. When installed under exposure to UV radiation, the HDPE material is equipped with corresponding protection.

It is recommended not to install duct with an inner diameter less than the specifications given below.

$$\frac{\text{Cross-sectional area of prestressing steel}}{\text{Cross-sectional area of inner diameter of duct}} < 0.5$$

$$\frac{\text{Inner diameter of duct}}{\sqrt{\text{Cross-sectional area of prestressing steel}}} > 1.65$$

For long tendons, > 70 m, inner diameter of duct should be increased by (7–15) %.

1.5 Deviator

The deviator transfers the deviation forces and friction forces of the tendon to the structure. Moreover, the deviator provides a smooth surface for support of the tendon. The deviator can be made of concrete, steel, or of other material, equivalent in terms of structural and surface requirements. See Annex 4 for installed deviators.

– As pre-installed duct section, pre-bent to the intended curvature. Adjacent to the deviator, the duct is connected with sleeves, collars, or by welding.

– A recess form is installed that provides an aperture with smooth surface and intended curvature for the duct. Permanent recess form for deviator of concrete can be made of PE, PP, steel, or other equivalent material. The duct is passed through the aperture of the deviator.

A deviation angle of $\alpha_2 \geq 3$ ° is arranged at both deviator ends, to avoid abrupt deviations of the tendon. To facilitate filling operation, a vent is arranged at the deviator.

1.6 Friction losses

For calculation of loss of prestressing force due to friction Coulomb's law applies. Calculation of friction loss is by the equation

$$\Delta P_\mu = P_0 \cdot \left(1 - e^{-\mu \cdot \theta}\right)$$

Where

ΔP_μ .... kN............ Loss of prestressing force due to friction at a distance x along the tendon

P_0 .... kN............ Prestressing force at x = 0 m

μ..........rad^{-1} .... Friction coefficient prestressing steel strand to sheath, see Table 2

θ...........rad .... Sum of angular displacements over distance x, irrespective of direction or sign

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x .... m .... Distance along the tendon from the point where the prestressing force is equal to P_0

NOTE 1 1 rad = 1 m/m = 1

NOTE 2 Wobble effects are neglected for external tendons.

The friction coefficient, μ, depends on various factors. Among them are duct and contact surface conditions, number of prestressing steel strands, bending radius, prestressing force, stiffness of duct, lubrication of prestressing steel strands, etc..

Table 2: Friction coefficient

Sheath	Range of values	Recommended values
	μ	μ
—	rad^{-1}	rad^{-1}
External tendon with smooth steel duct	0.17–0.20	0.19
External tendon with smooth plastic duct	0.10–0.14	0.12

NOTE Application of PT system does not consider the use of tensile elements or steel duct with corroded or rusted surfaces.

1.7 Slip at anchorage

In final locking, the prestressing steel stands slightly slip into the anchor head at the stressing anchorage, causing loss of prestressing force, see Figure 1. At fixed anchorage the same slip is taken into account for calculation of tendon elongation but does not result in loss of prestressing force.

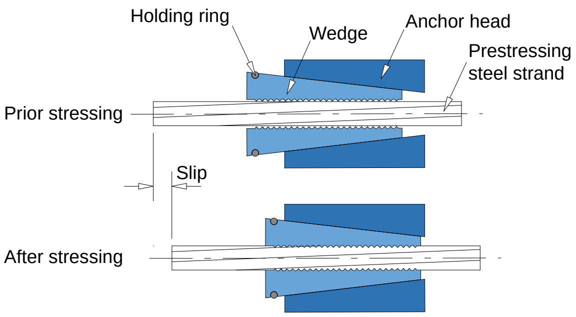

Figure 1 Slip at anchorage – Schematic

Anchorage slip is taken into consideration in calculation of tendon elongation and prestressing force. Slip at stressing anchorage and at fixed anchorage is 6 mm.

1.8 Concrete strength at time of stressing

Concrete in conformity with EN 206 is used.

The mean concrete compressive strength at the time of stressing, see also Annex 8, Annex 9, Annex 10, Annex 11, and Annex 12, is

$f_{cm,\,0,\,cube}$ = 40 MPa, cube strength, 150 mm cube.

The concrete test specimens are subjected to the same curing conditions as the structure.

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For partial prestressing with 30 % of the full prestressing force the actual mean concrete compressive strength is at least 0.5 · $f_{cm, 0, cube}$. Intermediate values may be interpolated linearly according to Eurocode 2.

1.9 Minimum centre spacing and edge distance

Minimum centre spacing, X_2, and edge distances, X_1, are given in Annex 8.

However, the values specified in Annex 8 for centre spacing between anchorages may be modified, i.e., reduced in one direction by up to 15 %. Modified centre spacing remains larger than helix outer diameter and placement of the additional stirrup reinforcement is still possible. Thereby, in the perpendicular direction the centre spacing is increased by the same percentage. The area of the rectangle defined by the modified centre spacings is at least the area of the square, defined by the centre spacing specified in Annex 8, i.e., $X_2 \cdot X_2$. The corresponding minimum edge distance is calculated by

$$X_1 = \frac{X_2}{2} - 10\text{ mm} + c$$

Where

X_1 .... mm .... Edge distance

X_2 .... mm .... Centre spacing

c .... mm .... Concrete cover

Standards and regulations on concrete cover in force at the place of use are observed.

1.10 Permanent corrosion protection

1.10.1 General

Corrosion protection of all components is of primary concern, to ensure, the performance of the PT system is maintained throughout the intended working life of the structure. In any case, corrosion protection is applied to tendons and is appropriate for the intended use and expected environmental and exposure conditions. Corrosion protection of external tendons is primarily achieved by suitable ducts, and appropriate corrosion protection filling material.

Metallic surfaces that are exposed to the environment such as parts of anchorages are protected against corrosion as per EN ISO 12944.

In the course of preparing the European Technical Assessment no characteristic has been assessed for components and materials of the corrosion protection system. In execution, all components and materials are selected according to the standards and regulations in force at the place of use. In the absent of such standards or regulations, components and materials in accordance with EAD 160004-00-0301 are deemed as acceptable.

1.10.2 Filling of tendon

Corrosion protection filling material and filling operation on site have a major effect on corrosion protection and therefore durability of the PT system. Where components of the PT systems are exposed to the environment such as anchorages, vents and drains, etc., these are effectively sealed to protect tensile elements and anchorage components.

Sheaths and anchorages are completely filled with

– Cementitious grout in conformity with EN 447

– Cementitious grout, wax, or grease according to EAD 160027-00-0301

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Components

1.11 Prestressing steel strands

Only 7-wire prestressing steel strands with characteristics according to Table 3 are used, see also Annex 17.

Table 3: Prestressing steel strands

Maximum characteristic tensile strength	f_{pk}	MPa	1 860
Nominal diameter	d	mm	15.7
Nominal cross-sectional area	A_p	mm^2	150
Mass of prestressing steel	M	kg/m	1.172

In a single tendon only prestressing steel strands spun in the same direction are used.

In the course of preparing the European Technical Assessment, no characteristic has been assessed for the prestressing steel strands. In execution, a suitable prestressing steel strand that conforms to Annex 17 and is according to the standards and regulations in force at the place of use is taken.

1.12 Anchorage

1.12.1 General

The components of the LMK External Post Tensioning System with 2 to 37 strands are in conformity with the specifications given in Annex 1, Annex 2, Annex 7, Annex 8, Annex 9, Annex 10, Annex 11, Annex 12, and the technical file[2]. Therein the component dimensions, materials, and material identification data with tolerances are given. The material specifications of the components are listed in Annex 16.

1.12.2 Anchor head

The anchor head is made of steel according to EN ISO 683-2 and provided with conical holes drilled in parallel and in a specific pattern to accommodate prestressing steel stands with wedges, see Annex 1. The anchor head transfers the prestressing force from prestressing steel strands to bearing plate.

NOTE Anchor head that grips the prestressing steel strand with wedge is commonly called wedge plate.

The back exits of the conical bores are provided with bell mouth openings or polymer rings are applied. In addition, threaded bores are provided to attach a retaining plate, see Annex 1.

1.12.3 Bearing plate

The bearing plate is made of cast iron according to EN 1563, supports the anchor head and transfers the prestressing force into the structural concrete by conical shape and protruding ribs on the outer surface.

Inlet with inner thread is arranged in front face of the bearing plate – fascial bearing plate. A tube is fitted in the inlet for filling, see Annex 2.

[2] The technical file of the European Technical Assessment is deposited at Österreichisches Institut für Bautechnik.

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1.12.4 Wedge

The wedge is a conical multi piece part made of steel according to EN ISO 683-3 and anchors one single prestressing steel strand in a conical hole of the anchor head. Thereby the prestressing force of each individual tensile element is transferred to the anchor head.

The wedge consists of two pieces with teeth on the inner surface to anchor the prestressing steel strand by indentation. The pieces are hold together with plastic holding ring, O-ring, see Annex 1.

1.12.5 Helix and additional reinforcement

Shapes of additional reinforcement are helix, square stirrups, and “W”-stirrups and are made of ribbed reinforcing steel, see Annex 7. Grade and dimensions conform to the specifications given in Annex 9, Annex 10, Annex 11, Annex 12, and Annex 16.

In addition to the reinforcement according to the design of the structure, additional reinforcement is placed at the anchorage where the prestressing force is introduced in the structural concrete – anchorage zone. The additional reinforcement confines the structural concrete of the anchorage zone to resist the bearing plate loaded by the prestressing force. Helix and stirrups are arranged exactly parallel and centric to the tendon axis and are firmly fastened to avoid displacement during placing and compaction of the concrete.

If required for a specific project design, the reinforcement given in Annex 7, Annex 9, Annex 10, Annex 11, and Annex 12 may be modified in accordance to the respective regulations in force at the place of use as well as to the relevant approval of the local authorities and of the ETA holder in order to provide equivalent performance.

1.12.6 Grouting and protection cap

Corrosion protection of the anchor head can be established with a grouting cap or protection cap in steel or plastic. The cap is attached to the bearing plate with bolts. The grouting or protection cap covers the end of the tendon at the anchorage.

Inlet for grouting the tendon is either the inlet of the bearing plate or the inlet of the grouting cap. The grouting port of the cap allows for filling the cap with corrosion protection filling material in order to ensure proper protection of the tendon end and proper sealing, see Annex 2.

1.12.7 Material specifications

In Annex 16 the material specifications of the components are given.

2 Specification of the intended use in accordance with the applicable European Assessment Document (hereinafter EAD)

2.1 Intended use

The PT system is intended to be used for the prestressing of structures. The specific intended use is

– External tendon for concrete and composite structures with a tendon path situated outside the cross section of the structure or member but inside its envelope. Included are ring tendons for e.g. tanks, placed circumferentially onto the outer surface of the structure.

2.2 Assumptions

2.2.1 General

Concerning product packaging, transport, storage, maintenance, replacement, and repair it is the responsibility of the manufacturer to undertake the appropriate measures and to advise his clients on transport, storage, maintenance, replacement, and repair of the product as he considers necessary.

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2.2.2 Packaging, transport, and storage

Advice on packaging, transport, and storage includes.

- Temporary protection of prestressing steel and components in order to prevent corrosion during transport from production site to job site
- Transportation, storage, and handling of prestressing steel and other components in a manner as to avoid damage by mechanical or chemical impact
- Protection of prestressing steel and other components from moisture. Prestressing steel and components are stored clear from ground, in a sheltered dry area with proper ventilated to avoid high humidity and protect the material from damage and dust.
- Keeping tensile elements separate from areas where welding operations are performed

2.2.3 Design

2.2.3.1 General

It is the responsibility of the ETA holder to ensure that all necessary information on design and installation is submitted to those responsible for design and execution of the structures executed with the LMK External Post Tensioning System with 2 to 37 strands.

Design and reinforcement of the anchorage zone and at the deviator permit correct placing and compacting of concrete. Design of the structure permits correct installation and stressing of the tendons and correct application of the corrosion protection, in particular filling.

Protection of the external tendons against damage by e.g. impact of vehicles, vibrations, etc. should be considered.

2.2.3.2 Anchorage recess, centre spacing and edge distance

The dimensions of the anchorage recess are adapted to the jack used for stressing. The ETA holder saves for reference information on minimum dimensions of the anchorage recess and appropriate clearance behind the anchorage. The formwork for the anchorage recess should be slightly conical for ease of removal. Its final geometry is specific to the specifications of each project design.

In case of internal anchorages fully embedded in concrete, the recesses are designed so as to permit a reinforced concrete cover with the required dimensions and in any case with a thickness of at least 30 mm. However, exposed surfaces of bearing plate and grouting cap are provided with corrosion protection if required.

Bursting out of prestressing steel in case of failure of an external tendon is prevented by e.g. a cover of reinforced concrete, suitable for the expected impact energy.

Minimum centre spacing and edge distance are given in Annex 8. These minimum dimensions should not be considered where adjacent tendons are stressed simultaneously. In such a case spacing and distance need to be adapted accordingly. Concrete cover as required at the place of use are considered with the edge distance.

2.2.3.3 Reinforcement in the anchorage zone

The anchorage transfers the prestressing force to the structure by means of the bearing plate embedded in concrete. The anchorage zone with bearing plate is reinforced with additional reinforcement as given in Annex 7, Annex 9, Annex 10, Annex 11, and Annex 12.

Verification of transfer of prestressing forces to the structural concrete is not required if centre spacing and edge distances of the anchorages as well as grade and dimensions of additional reinforcement, see Annex 7, Annex 9, Annex 10, Annex 11, Annex 12, and Annex 16 are met. The forces outside the area of the additional reinforcement are verified and, if necessary, dealt with by appropriate reinforcement.

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The reinforcement as specified in the design of the structure is not considered as additional reinforcement nor substitutes the specific additional reinforcement of the PT system. Reinforcement exceeding the required reinforcement in the design of the structure may be considered as additional reinforcement, provided appropriate placing and vibration of concrete are possible.

If required for a specific project design, the reinforcement given in Annex 7, Annex 9, Annex 10, Annex 11, and Annex 12 may be modified in accordance with the respective regulations in force at the place of use as well as with the relevant approval of the local authority and of the ETA holder to provide equivalent performance.

2.2.3.4 Tendon layout

The tendon layout is specified in the design of the structure. At the deviator and at a cuved tendon section, minimum radius of curvature, R_{min}, and minimum straight length ahead a curved tendon section, M_{min}, are given in Annex 5 and Annex 6. External diameters for regular ducts are listed in Annex 5 and Annex 6.

2.2.3.5 Maximum prestressing force

Prestressing and overstressing forces are specified in the respective standards and regulations in force at the place of use. In Annex 14 and Annex 15 the respective maximum values according to Eurocode 2 are listed.

2.2.3.6 Losses of prestressing force

The effective prestressing force in a tendon differs from the initial prestressing force in the jack prior to locking for various reasons. The main reasons are given in Table 4.

Table 4: Short-term and long-term losses

Short term – Initial losses	Long term – Time dependent
Friction losses, curvature and wobble	Creep of concrete
Concrete elastic deformation	Shrinkage of concrete
Slip at anchorage	Prestressing steel strand relaxation

For losses due to friction along the tendon see Clause 1.6.

When the load is transferred from the jack to the anchorage, slip occurs as the prestressing steel strands are anchored by grip of the wedges in the anchor head and possible anchor head setting, see Clause 1.7. The result is shortening of the tendon and loss in prestressing force is the consequence. Due to friction, these losses only affect a certain length of the tendon.

NOTE In case of tendons short in length, < 15 m, wedge slip causes important losses.

In general, all tendons in a section are not stressed simultaneously. There are losses of prestressing force due to elastic shortening of the concrete by subsequent stressing of tendons. Further losses in the course of time are the result of creep and shrinkage of concrete and relaxation of prestressing steel stands.

Loss in prestressing force by elastic shortening and creep and shrinkage of concrete as well as relaxation of prestressing steel strands are not specific to the PT system. These losses are considered according to Eurocode 2 and the standards and regulations in force at the place of use.

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2.2.3.7 Tendon in masonry structure – Load transfer to the structure

Load transfer of prestressing force to masonry structures is via concrete or steel members, designed according to the European Technical Assessment, in particular according to the Clauses 1.8, 1.9, 2.2.3.2, and 2.2.3.3 or according to Eurocode 3 respectively.

The concrete or steel members have such dimensions as to permit a force of 1.1 · F_{pk} being transferred into the masonry. The verification is performed according to Eurocode 6 as well as to the respective standards and regulations in force at the place of use.

Deviators are made of concrete or steel. The transfer of the forces from the deviator to the masonry is verified according to Eurocode 6 as well as to the respective standards and regulations in force at the place of use.

2.2.4 Installation

2.2.4.1 General

It is assumed that the product will be installed according to the manufacturer's instructions or – in absence of such instructions – according to the usual practice of the building professionals. The execution of works should follow EN 13670, Execution of concrete structures.

Assembly and installation of tendons are only carried out by qualified PT specialist companies with the required resources and experience in the use of bonded multi-strand post-tensioning systems, see CWA 14646. The company's PT site manager has a certificate, stating that she or he has been trained by the ETA holder and that she or he possesses the necessary qualification and experience with the LMK External Post Tensioning System with 2 to 37 strands.

All materials, i.e., prestressing steel strands, anchorage components, additional reinforcement, sheaths, ancillaries, etc. are delivered on site prior to installation commencement. The PT site manager should verify all materials did arrive in conditions as specified and in sufficient quantity. Tendons and material are carefully handled during assembly, transport, storage, and installation.

The tendons may be assembled on site.

2.2.4.2 Installation of bearing plate

Threaded holes on the face of the bearing plate facilitate proper fastening on the formwork and the recess form. The bearing plate is placed exactly perpendicular to the axis of the tendon. Installation on the formwork is leak tight to avoid any penetration of concrete during concreting.

2.2.4.3 Installation of deviator

For proper installation it is recommended to use a guide tool between successive deviators for pre-adjustment. The deviator is properly connected to the formwork and the reinforcement mesh to avoid any movement during concreting. If necessary, inserts are placed in the deviator to avoid deformation. The minimum radius of curvature conforms to Clause 1.4.

2.2.4.4 Concreting

Before placing the concrete, a final check of the installed anchorages and deviators is carried out by the person responsible for tendon placement. In case of minor damage, when replacement does not deem necessary, the damaged area is cleaned and sealed with an adhesive tape.

All openings provided for duct installation are sealed to avoid ingress of concrete.

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2.2.4.5 Duct installation

The duct is connected to the anchorages, connected to or threaded through the deviators, and placed on supports with a spacing of (2–4) m. The connection duct to anchorage shall be executed tension-proof by suitable means. Loading of the duct with prestressing steel strands is taken into account for the supports. All joints are finished leak tight by welding or by mechanical techniques avoiding welding operations on site.

All filling ancillaries such as tubes, valves, etc. are connected tension proof and leak tight to the duct.

2.2.4.6 Completing tendon installation

The prestressing steel strands are pushed or pulled into the duct. Overlengths of prestressing steel strands are provided at stressing end as to properly accommodate jack and jack wedges.

Protruding prestressing steel strands as well as bearing plates are protected from water, dirt, damages, etc. and should be covered and sealed.

2.2.4.7 Stressing operation, safety at work

With a mean concrete compressive strength in the anchorage zone according to the values laid down in Annex 8, Annex 9, Annex 10, Annex 11, and Annex 12, full prestressing may be applied. The prestressing steel strands are arranged, and the anchor head is placed by inserting the prestressing steel strands through the holes of the anchor head. At each prestressing steel strand, a wedge is inserted in the respective conical hole of the anchor head. The fixed anchorage remains accessible throughout the whole stressing operation.

The jack is placed, resting on the anchor head. The force applied on the tendon is measured with a calibrated pressure-force-relation, specific to the jack.

An initial force of 5–10 % of the final prestressing force is applied in order to facilitate alignment of prestressing steel strands and anchor head. The initial force is applied to arrange the prestressing steel strands along the tendon as well as to define the starting point for elongation measurement. Optionally, the tendon is anchored at that stage, the jack is released and moved backwards to mark the entering points of the prestressing steel strands into the wedges as starting points for elongation measurement.

Stressing is performed according to a predetermined stressing schedule. Overstressing is permitted under the condition given in Annex 14. Stressing continues until the final prestressing force is attained. Tendon elongation is measured and compared with the previously calculated value.

Stressing is completed once the scheduled prestressing force and the scheduled elongation are attained. Finally, the prestressing steel strands are anchored with the wedges in the conical holes of the anchor head.

The stressing operations, including applied prestressing force and measured elongation of each tendon are documented in stressing records.

The safety-at-work and health protection regulations shall be complied with.

2.2.4.8 Filling operation

Corrosion protection filling materials, i.e. grout, wax, and grease are in accordance with EN 447 or special filling materials in accordance with EAD 160027-00-0301.

Tendons are filled in due time after stressing is competed. If the period between stressing and filling is unusually long, temporary protection means are implemented. An example is flushing the tendon with dry air.

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The corrosion protection filling material is injected through the inlet tubes until it escapes from the outlet tubes with the same consistency and is free of air bubbles. All vents and inlets are sealed immediately after filling.

The results of the filling operation of each tendon are documented in filling records.

2.2.4.9 Welding

Welding is not intended and it is not permitted to weld on built-in components of PT systems.

In case of welding operations near tendons precautionary measures are required to avoid damage of tensile elements or corrosion protection system.

Welding of plastic material may be performed after tendon installation.

2.2.4.10 Restressing of tendon

An external tendon prior to grouting or filling, or an external tendon filled with wax or grease can be re-stressed with the same wedges, provided that the wedge bites after re-stressing are at prestressing steel strands surfaces free of any previous bites and no wedge bite remains inside the final length of the tendon between anchorages.

2.2.4.11 Replacing of tendon

Replacing of a tendon needs to be considered in the design of the structure. A replaceable tendon is filled with wax or grease. Stressing and fixed anchorages are accessible and clearance behind the anchorages is provided for handling and stressing.

Adequate overlengths of prestressing steel strands remain at the stressing anchorage for full release of prestressing force. The overlengths are protected against corrosion and a special cap is attached.

Possible wear of sheathing from stressing, release of prestressing force, and stressing of the replaced tendon is considered.

2.3 Assumed working life

The European Technical Assessment is based on an assumed working life of the PT system of 100 years, provided that the PT system is subject to appropriate installation, use, and maintenance, see Clause 2.2. These provisions are based upon the current state of the art and the available knowledge and experience.

In normal use conditions the real working life may be considerably longer without major degradation affecting the basic requirements for construction works[3].

The indications given as to the working life of the construction product cannot be interpreted as a guarantee, neither given by the product manufacturer or his representative nor by EOTA nor by the Technical Assessment Body, but are regarded only as a means for expressing the expected economically reasonable working life of the product.

[3] The real working life of a product incorporated in a specific works depends on the environmental conditions to which that works are subject, as well as on the particular conditions of design, execution, use, and maintenance of that works. Therefore, it cannot be excluded that in certain cases the real working life of the product may also be shorter than the assumed working life.

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3 Performance of the product and references to the methods used for its assessment

3.1 Essential characteristics

The performances of the PT system for the essential characteristics are given in Table 5.

Table 5: Essential characteristics and performances of the product

Essential characteristic	Method of assessment	Product performance
Basic requirement for construction works 1: Mechanical resistance and stability		
Resistance to static load	See Clause 3.2.1.1.	See Clause 3.2.1.1.
Resistance to fatigue	See Clause 3.2.1.2.	See Clause 3.2.1.2.
Load transfer to the structure	See Clause 3.2.1.3.	See Clause 3.2.1.3.
Friction coefficient	EAD 160004-00-0301, Clause 2.2.4.	See Clause 3.2.1.4.
Deviation, deflection (limits) for external tendon	EAD 160004-00-0301, Clause 2.2.5	See Clause 3.2.1.5.
Assessment of assembly	See Clause 3.2.1.6.	See Clause 3.2.1.6.
Corrosion protection	See Clause 3.2.1.7.	See Clause 3.2.1.7.
Basic requirement for construction works 2: Safety in case of fire		
Reaction to fire	See Clause 3.2.2.1.	See Clause 3.2.2.1.
Basic requirement for construction works 3: Hygiene, health, and the environment		
Content, emission, and/or release of dangerous substances	See Clause 3.2.3.	See Clause 3.2.3.
Basic requirement for construction works 4: Safety and accessibility in use		
Not relevant. No characteristic assessed.	—	
Basic requirement for construction works 5: Protection against noise		
Not relevant. No characteristic assessed.	—	
Basic requirement for construction works 6: Energy economy and heat retention		
Not relevant. No characteristic assessed.	—	
Basic requirement for construction works 7: Sustainable use of natural resources		
No characteristic assessed.	—	

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3.2 Product performance

3.2.1 Mechanical resistance and stability

3.2.1.1 Resistance to static load

The PT system as described in the ETA meets the acceptance criteria of EAD 160004-00-0301, Clause 2.2.1. The characteristic values of maximum force, F_{pk}, of the tendon with prestressing steel strands according to Annex 17 are listed in Annex 13 and Annex 14.

3.2.1.2 Resistance to fatigue

The PT system as described in the ETA meets the acceptance criteria of EAD 160004-00-0301, Clause 2.2.2. The characteristic values of maximum force, F_{pk}, of the tendon with prestressing steel strands according to Annex 17 are listed in Annex 13 and Annex 14.

Fatigue resistance of anchorages was tested and verified with an upper force of $0.65 \cdot F_{pk}$, a fatigue stress range of 80 MPa, and $2 \cdot 10^6$ load cycles.

3.2.1.3 Load transfer to the structure

The PT system as described in the ETA meets the acceptance criteria of EAD 160004-00-0301, Clause 2.2.3. The characteristic values of maximum force, F_{pk}, of the tendon with prestressing steel strands according to Annex 17 are listed in Annex 13 and Annex 14.

The fulfilment of the stabilisation criteria and the requirements for crack widths in the load transfer tests were verified up to $0.8 \cdot F_{pk}$.

3.2.1.4 Friction coefficient

For friction losses including friction coefficient see Clause 1.6.

3.2.1.5 Deviation, deflection (limits) for external tendon

For minimum radii of curvature see Clause 1.4.

3.2.1.6 Assessment of assembly

The PT system as described in the ETA meets the acceptance criteria of EAD 160004-00-0301, Clause 2.2.7.

3.2.1.7 Corrosion protection

The PT system as described in the ETA meets the acceptance criteria of EAD 160004-00-0301, Clause 2.2.13.

3.2.2 Safety in case of fire

3.2.2.1 Reaction to fire

The performance of components made of steel or cast iron is Class A1 without testing.

The performance of components of other materials has not been assessed.

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3.2.3 Hygiene, health, and the environment

According to the manufacturer's declaration, the PT system does not contain dangerous substances.

– SVOC and VOC

  The performance of components made of steel or cast iron that are free of coating with organic material is no emission of SVOC and VOC.

  The performance of components of other materials has not been assessed.

– Leachable substances

  The product is not intended to be in direct contact to soil, ground water, and surface water.

3.3 Assessment methods

The assessment of the essential characteristics in Clause 3.1 of the PT system, for the intended use, and in relation to the requirements for mechanical resistance and stability, safety in case of fire, and for hygiene, health and the environment, in the sense of the basic requirements for construction works № 1, 2, and 3 of Regulation (EU) № 305/2011, has been made in accordance with Annex A of EAD 160004-00-0301, Post-tensioning kits for prestressing of structures, for

– Item 5, External tendon

3.4 Identification

The European Technical Assessment for the LMK External Post Tensioning System with 2 to 37 strands is issued on the basis of agreed data that identify the assessed product[4]. Changes to materials, to composition, or to characteristics of the product, or to the production process could result in these deposited data being incorrect. Österreichisches Institut für Bautechnik should be notified before the changes are introduced, as an amendment of the European Technical Assessment is possibly necessary.

4 Assessment and verification of constancy of performance (hereinafter AVCP) system applied, with reference to its legal base

4.1 System of assessment and verification of constancy of performance

According to Commission Decision 98/456/EC, the system of assessment and verification of constancy of performance to be applied to LMK External Post Tensioning System with 2 to 37 strands is System 1+. System 1+ is detailed in Commission Delegated Regulation (EU) № 568/2014 of 18 February 2014, Annex, point 1.1, and provides for the following items.

(a) The manufacturer shall carry out

  (i) factory production control;

  (ii) further testing of samples taken at the manufacturing plant by the manufacturer in accordance with the prescribed test plan[5].

---

[4] The technical file of the European Technical Assessment is deposited at Österreichisches Institut für Bautechnik.

[5] The prescribed test plan has been deposited with Österreichisches Institut für Bautechnik and is handed over only to the notified product certification body involved in the procedure for the assessment and verification of constancy of performance. The prescribed test plan is also referred to as control plan.

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(b) The notified product certification body shall decide on the issuing, restriction, suspension, or withdrawal of the certificate of constancy of performance of the construction product on the basis of the outcome of the following assessments and verifications carried out by that body

(i) an assessment of the performance of the construction product carried out on the basis of testing (including sampling), calculation, tabulated values, or descriptive documentation of the product;

(ii) initial inspection of the manufacturing plant and of factory production control;

(iii) continuing surveillance, assessment, and evaluation of factory production control;

(iv) audit-testing of samples taken by the notified product certification body at the manufacturing plant or at the manufacturer's storage facilities.

4.2 AVCP for construction products for which a European Technical Assessment has been issued

Notified bodies undertaking tasks under System 1+ shall consider the European Technical Assessment issued for the construction product in question as the assessment of the performance of that product. Notified bodies shall therefore not undertake the tasks referred to in Clause 4.1, point (b) (i).

5 Technical details necessary for the implementation of the AVCP system, as provided for in the applicable EAD

5.1 Tasks for the manufacturer

5.1.1 Factory production control

The kit manufacturer exercises permanent internal control of the production. All the elements, procedures, and specifications adopted by the kit manufacturer are documented in a systematic manner in the form of written policies and procedures.

– Control of the incoming materials

  The manufacturer checks the incoming materials to establish conformity with their specifications.

– Inspection and testing

  Kind and frequency of inspections, tests, and checks, conducted during production and on the final product normally include.

  – Definition of the number of samples taken by the kit manufacturer
  – Material properties e.g., tensile strength, hardness, surface finish, chemical composition, etc.
  – Determination of the dimensions of components
  – Check correct assembly
  – Documentation of tests and test results

All tests are performed according to written procedures with suitable calibrated measuring devices. All results of inspections, tests, and checks are recorded in a consistent and systematic way. The basic elements of the prescribed test plan are given in Annex 18, conform to EAD 160004-00-0301, Table 3, and are specified in the quality management plan of the LMK External Post Tensioning System with 2 to 37 strands.

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The results of inspections, tests, and checks are evaluated for conformity. Shortcomings request the manufacturer to immediately implement measures to eliminate the defects.

– Control of non-conforming products

  Products, which are considered as not conforming to the prescribed test plan, are immediately marked and separated from such products that do conform. Factory production control addresses control of non-conforming products.

– Complaints

  Factory production control includes procedures to keep records of all complaints about the PT system.

The records are presented to the notified product certification body involved in continuous surveillance and are kept at least for ten years after the product has been placed on the market. On request, the records are presented to Österreichisches Institut für Bautechnik.

At least once a year the manufacturer audits the manufacturers of the components given in Annex 19.

5.1.2 Declaration of performance

The manufacturer is responsible for preparing the declaration of performance. When all the criteria of the assessment and verification of constancy of performance are met, including the certificate of constancy of performance issued by the notified product certification body, the manufacturer draws up the declaration of performance. Essential characteristics to be included in the declaration of performance for the corresponding intended use are given in Table 5.

5.2 Tasks for the notified product certification body

5.2.1 Initial inspection of the manufacturing plant and of factory production control

The notified product certification body establishes that, in accordance with the prescribed test plan, the manufacturing plant, in particular personnel and equipment, and the factory production control are suitable to ensure a continuous manufacturing of the PT system according to the given technical specifications. For the most important activities, EAD 160004-00-0301, Table 4 summarises the minimum procedure.

5.2.2 Continuing surveillance, assessment, and evaluation of factory production control

The activities are conducted by the notified product certification body and include surveillance inspections. The kit manufacturer is inspected at least once a year. Factory production control is inspected and samples are taken for independent single tensile element tests.

For the most important activities, the control plan according to EAD 160004-00-0301, Table 4 summarises the minimum procedure. It is verified that the system of factory production control and the specified manufacturing process are maintained, taking account of the control plan.

Each manufacturer of the components given in Annex 19 is audited at least once in five years. It is verified that the system of factory production control and the specified manufacturing process are maintained, taking account of the prescribed test plan.

The results of continuous surveillance are made available on demand by the notified product certification body to Österreichisches Institut für Bautechnik. When the provisions of the European Technical Assessment and the prescribed test plan are no longer fulfilled, the certificate of constancy of performance is withdrawn by the notified product certification body.

5.2.3 Audit-testing of samples taken by the notified product certification body at the manufacturing plant or at the manufacturer's storage facilities

During surveillance inspection, the notified product certification body takes samples of components of the PT system for independent testing. Audit-testing is conducted at least once a

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year by the notified product certification body. For the most important components, Annex 19 summarises the minimum procedures. Annex 19 conforms to EAD 160004-00-0301, Table 4. In particular, at least once a year, the notified product certification body also carries out one single tensile element test series according to EAD 160004-00-0301, Annex C.7 and Clause 3.3.4 on specimens taken from the manufacturing plant or at the manufacturer's storage facility.

Issued in Vienna on 19 April 2024
by Österreichisches Institut für Bautechnik

The original document is signed by

Thomas Rockenschaub
Deputy Managing Director

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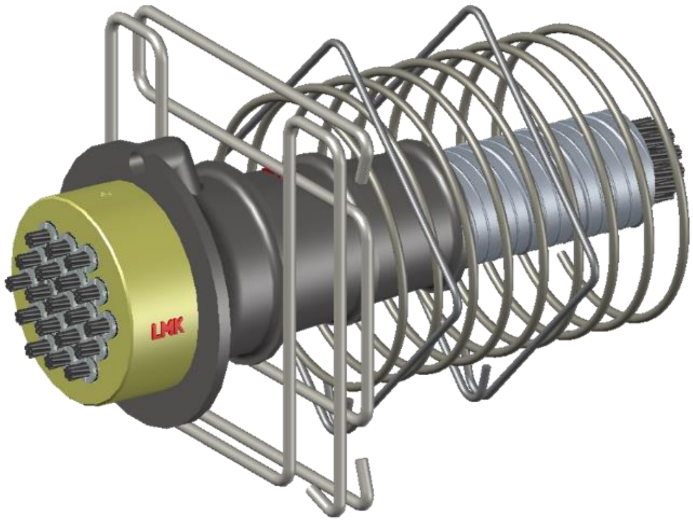
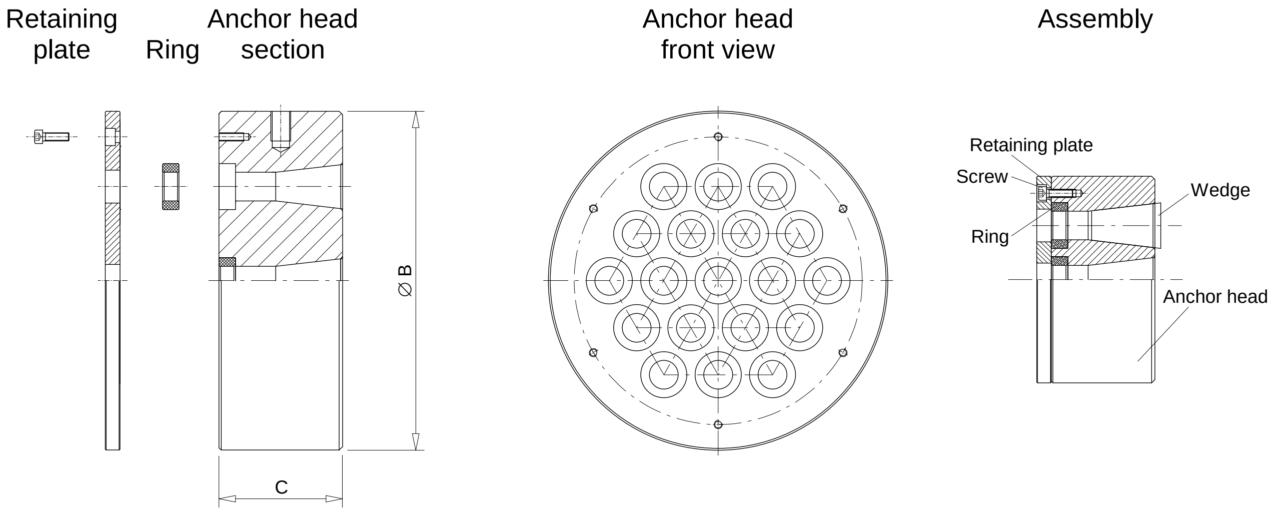
Stressing anchorage LMK-S and fixed anchorage LMK-F

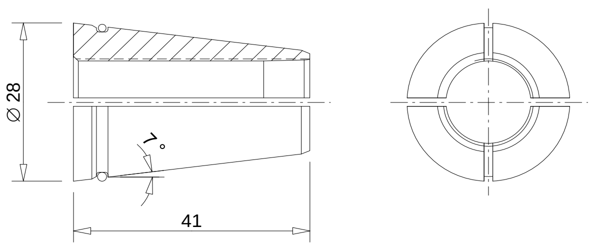


Anchor head



For dimensions ∅ B and C see Tables in Annex 9, Annex 10, Annex 11, and Annex 12.

Wedge



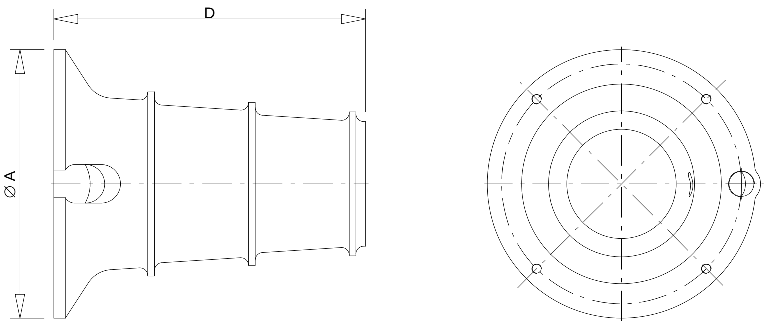
Dimensions in mm

LMK Post Tensioning System	**LMK External Post-Tensioning System with 2 to 37 strands** Anchorage – Overview Anchor head and wedge	**Annex 1** of European Technical Assessment **ETA-24/0184** of 19.04.2024

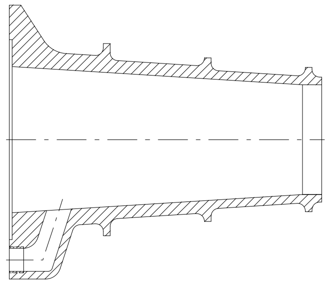
Bearing plate

Top view

Front view

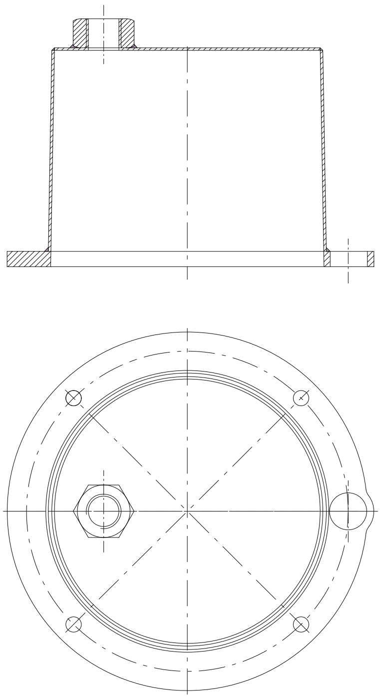


Section



For dimensions ∅ A and D see Tables in Annex 9, Annex 10, Annex 11, and Annex 12.

Injection cap



LMK Post Tensioning System	**LMK External Post-Tensioning System with 2 to 37 strands** Anchorage Bearing plate and injection cap	**Annex 2** of European Technical Assessment **ETA-24/0184** of 19.04.2024

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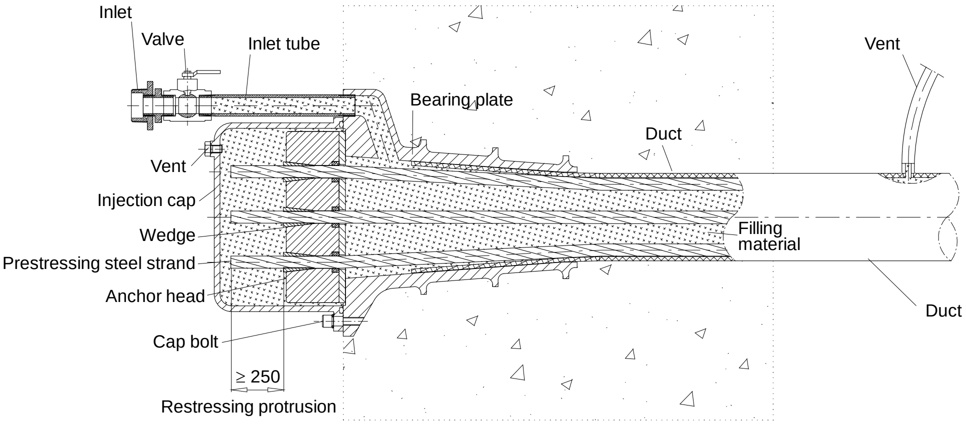
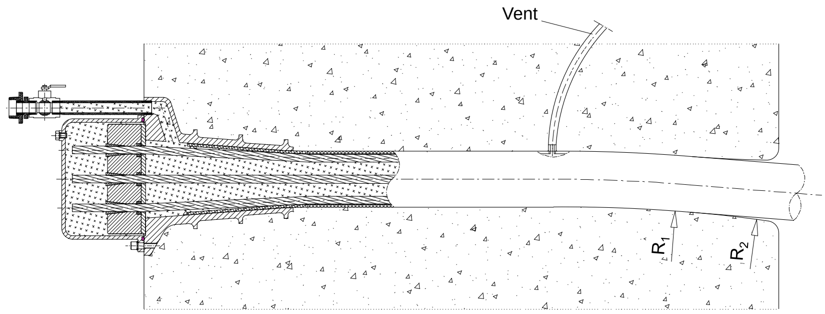
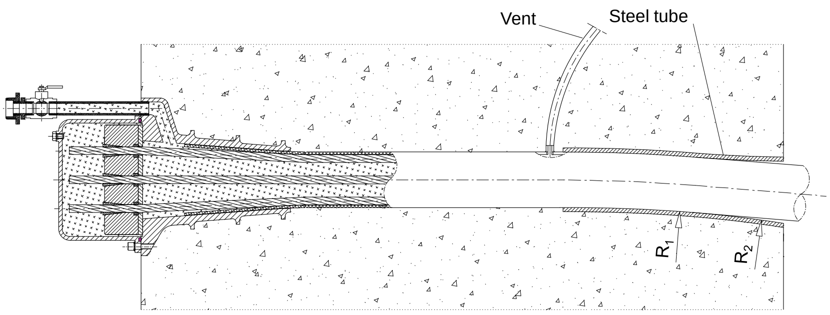


Dimensions in mm





Minimum straight length after anchor head, M_{min}, according to Annex 5 and Annex 6.

Key

$R_1 \geq R_2 \geq R_{min}$

LMK Post Tensioning System	**LMK External Post-Tensioning System with 2 to 37 strands** Overview on anchorage assembly	**Annex 3** of European Technical Assessment **ETA-24/0184** of 19.04.2024

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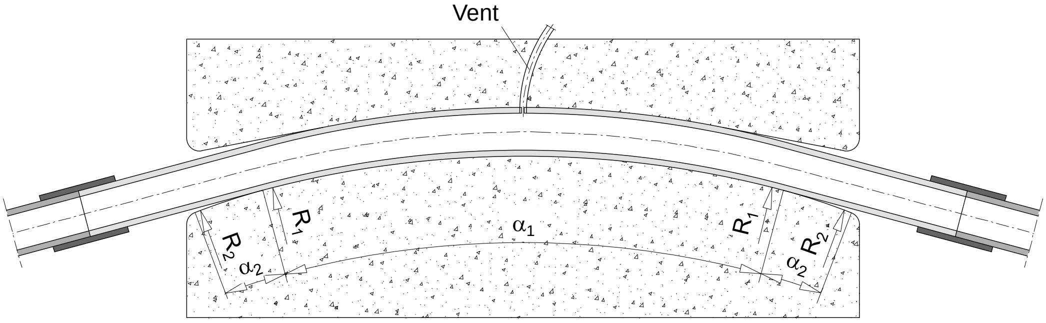

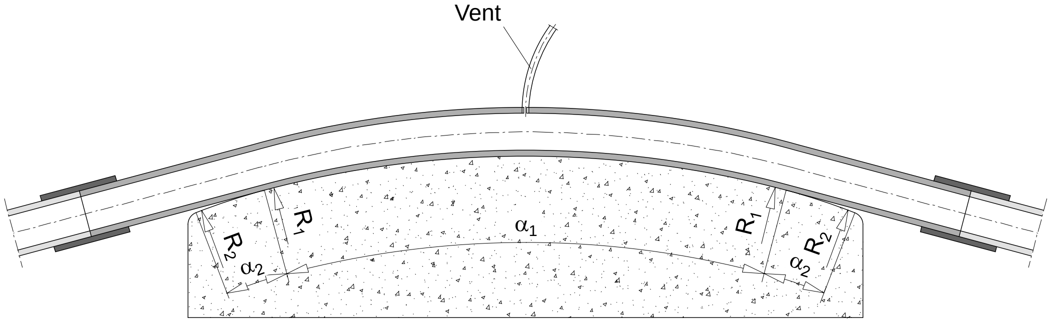

Key

$R_1 \geq R_2 \geq R_{min}$
α_1 .... Deviation
α_2 .... Additional deviation, ≥ 3 °
For R_{min} see Annex 5 and Annex 6.

LMK Post Tensioning System	**LMK External Post-Tensioning System with 2 to 37 strands** Overview on deviators	**Annex 4** of European Technical Assessment **ETA-24/0184** of 19.04.2024

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Table 6: Dimensions of steel duct

Number of strands	Steel duct			
	External diameter $\varnothing_e$ 1)	Wall thickness t 1)	Minimum radius of curverture R_{min}	Minimum straight length M_{min}
	mm	mm	m	m
2	48.3	1.6	2.0	0.8
3	48.3	1.6	2.0	0.8
4	48.3	1.6	2.0	0.8
5	76.1	1.6	2.0	0.8
6	76.1	1.6	2.5	0.8
7	76.1	1.6	2.5	0.8
8	76.1	1.6	2.5	1.0
9	88.9	1.6	2.5	1.0
10	88.9	1.6	2.5	1.0
11	88.9	1.6	2.5	1.0
12	88.9	1.6	2.5	1.0
13	88.9	1.6	3.0	1.0
14	88.9	1.6	3.0	1.0
15	88.9	1.6	3.0	1.0
16	88.9	1.6	3.0	1.0
17	114.3	2.3	3.0	1.0
18	114.3	2.3	3.0	1.0
19	114.3	2.3	3.0	1.0
20	114.3	2.3	3.5	1.0
21	114.3	2.3	3.5	1.0
22	114.3	2.3	3.5	1.5
23	114.3	2.3	3.5	1.5
24	114.3	2.3	3.5	1.5
25	114.3	2.3	3.5	1.5
26	127.0	2.6	3.5	1.5
27	127.0	2.6	3.5	1.5
28	127.0	2.6	3.5	1.5
29	127.0	2.6	4.0	1.5
30	127.0	2.6	4.0	1.5
31	139.7	2.9	4.0	1.5
32	139.7	2.9	4.0	1.5
33	139.7	2.9	4.0	1.5
34	139.7	2.9	4.0	1.5
35	139.7	2.9	4.0	1.5
36	139.7	2.9	4.0	1.5
37	139.7	2.9	4.0	1.5

1) Dimensions are minimum nominal values.

Table 7: Dimensions of smooth PE duct

Number of strands	Smooth PE duct			
	External diameter $\varnothing_e$ [1)]	Wall thickness t [1)]	Minimum radius of curverture R_{min}	Minimum straight length M_{min}
	mm	mm	m	m
2	32	2.0	3.0	0.8
3	40	2.4	5.0	0.8
4	50	3.0	4.5	0.8
5	50	3.0	5.5	0.8
6	63	3.8	4.5	0.8
7	63	3.8	5.0	0.8
8	63	3.8	5.5	1.0
9	75	4.5	5.0	1.0
10	75	4.5	5.5	1.0
11	75	4.5	6.0	1.0
12	90	5.4	5.5	1.0
13	90	5.4	6.0	1.0
14	90	5.4	6.5	1.0
15	90	5.4	7.0	1.0
16	90	5.4	7.0	1.0
17	90	5.4	7.5	1.0
18	110	6.6	6.5	1.0
19	110	6.6	7.0	1.0
20	110	6.6	7.5	1.0
21	110	6.6	7.5	1.0
22	110	6.6	8.0	1.5
23	110	6.6	8.5	1.5
24	110	6.6	9.0	1.5
25	110	6.6	9.0	1.5
26	125	7.4	8.5	1.5
27	125	7.4	8.5	1.5
28	125	7.4	9.0	1.5
29	125	7.4	9.5	1.5
30	125	7.4	9.5	1.5
31	125	7.4	10.0	1.5
32	140	8.3	9.0	1.5
33	140	8.3	9.5	1.5
34	140	8.3	10.0	1.5
35	140	8.3	10.0	1.5
36	140	8.3	10.5	1.5
37	140	8.3	10.5	1.5

[1)] Dimensions are minimum nominal values.

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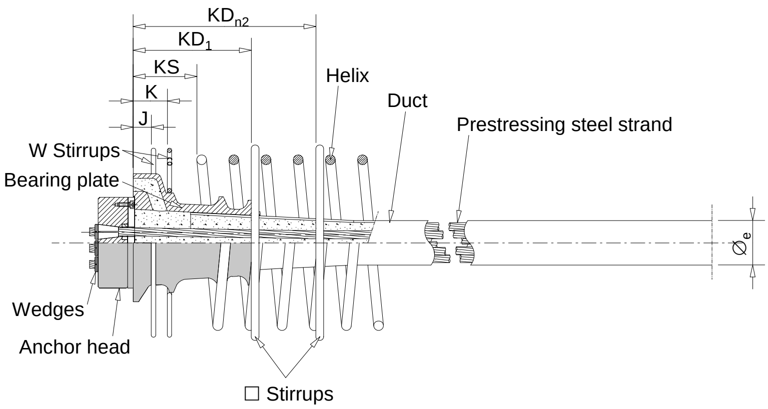
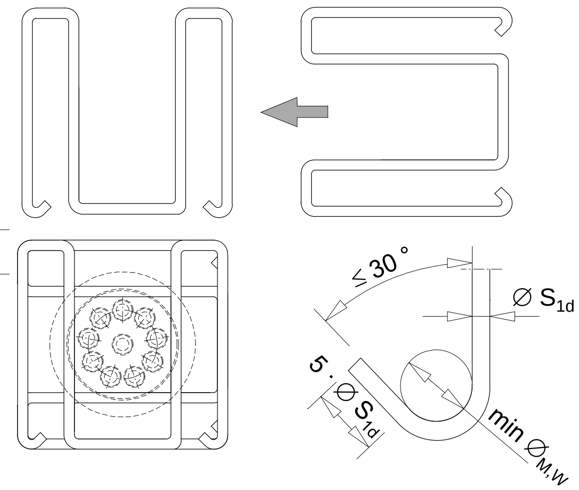
Anchorage, helix, and additional stirrup reinforcement

Assembled anchorage

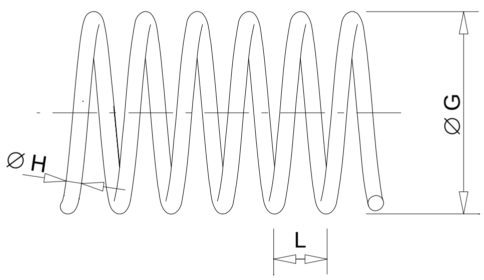


Additional reinforcement with W stirrups



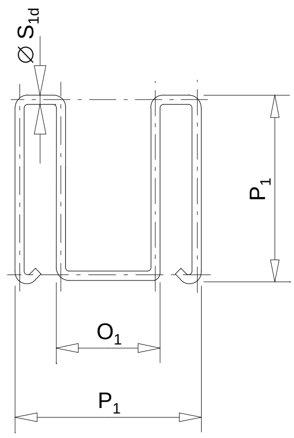
min $\varnothing_{M,W}$ ..... Minimum mandrel diameter for all bends of W stirrups

Helix

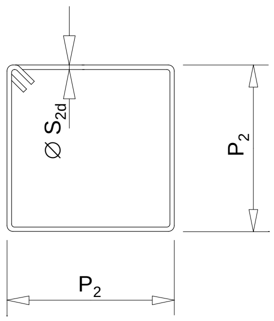


Number of turns N

W stirrup



☐, Square stirrup



For dimensions KS, $\varnothing$ H, $\varnothing$ G, L, N........ Helix
J, K, $\varnothing$ S_{1d}, O_1, P_1 .... W stirrup
KD_1 to KD_{n2}, $\varnothing$ S_{2d}, P_2... Square stirrup
see Tables in Annex 9, Annex 10, Annex 11, and Annex 12.
$\varnothing_e$ see Table in Annex 5 and Annex 6

LMK Post Tensioning System	**LMK External Post-Tensioning System with 2 to 37 strands** Anchorage Assembled anchorage, additional reinforcement	**Annex 7** of European Technical Assessment **ETA-24/0184** of 19.04.2024

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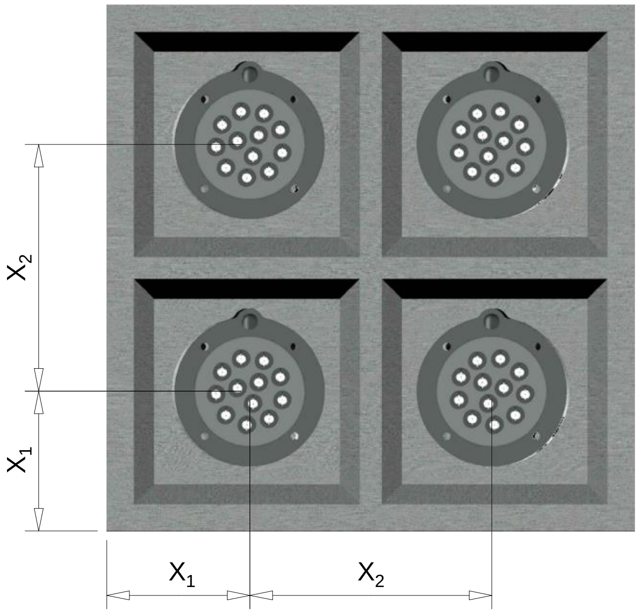
Table 8: Centre spacing and edge distance

Number of strands	Edge distance [1)], X_1	Centre spacing [1)], X_2
	Concrete strength at time of stressing $f_{cm,0,cube}$ = 40 MPa	
	mm	mm
2	130 + c	280
3	140 + c	300
4	150 + c	320
5	160 + c	340
6	170 + c	360
7	180 + c	380
8	190 + c	400
9	200 + c	420
10	205 + c	430
11	210 + c	440
12	220 + c	460
13	230 + c	480
14	240 + c	500
15	245 + c	510
16	255 + c	530
17	265 + c	550
18	270 + c	560
19	280 + c	580
20	285 + c	590
21	290 + c	600
22	295 + c	610
23	300 + c	620
24	305 + c	630
25	310 + c	640
26	315 + c	650
27	320 + c	660
28	325 + c	670
29	330 + c	680
30	340 + c	700
31	345 + c	710
32	350 + c	720
33	355 + c	730
34	360 + c	740
35	365 + c	750
36	370 + c	760
37	375 + c	770



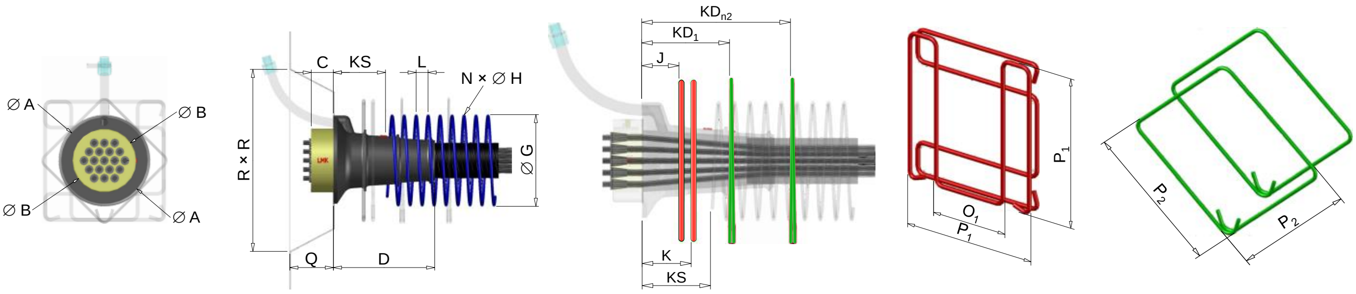
[1)] .... Minimum dimensions. However, see modifications according to Clause 1.9.

c .... Concrete cover of reinforcement placed in the same cross section

Table 9: Anchorage – Minimum concrete strength, additional reinforcement, details on dimensions

Anchorage		LMK-S-$_{DE}$-M-15 and LMK-F-$_{DE}$-M-15									
Number of strands	DE	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Strand arrangement											
Bearing plate	∅ A	132	136	150	165	180	180	210	210	225	225
	D	80	110	130	135	170	170	190	190	230	230
Anchor head	∅ B	91	91	102	115	126	126	146	146	166	166
	C	63	63	63	63	63	63	63	63	63	63
Minimum concrete strength at time of stressing, cube											
Minimum concrete strength in MPa	$f_{cm, 0}$	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**
Helix											
External diameter	∅ G	180	200	210	230	280	280	320	320	370	370
Number of turns	N	6	6	6	7	8	8	8	8	9	9
Wire diameter	∅ H	10	10	10	10	10	10	12	12	12	12
Dimension	L	50	50	50	50	50	50	60	60	60	60
Distance	KS	15	15	15	15	15	15	20	20	20	20
W Stirrups											
Dimensions	P_1	210	210	210	265	310	310	340	340	380	380
	O_1	110	110	110	140	160	160	190	190	195	195
	∅ S_{1d}	6	6	6	8	10	10	12	12	14	14
Number of layers	n1	2	2	2	2	2	2	2	2	2	2
Distance	J	65	65	65	65	60	60	70	70	70	70
	K	85	85	85	85	90	90	100	100	110	110
Square stirrups											
Dimensions	P_2	—	—	—	—	300	300	350	350	390	390
	∅ S_{2d}	—	—	—	—	8	8	8	8	8	8
Number of layers	n2	—	—	—	—	3	3	3	3	3	3
Distance	KD_1	—	—	—	—	140	140	145	145	170	170
	KD_2	—	—	—	—	270	270	275	275	320	320
	KD_3	—	—	—	—	400	400	405	405	470	470
	KD_4	—	—	—	—	—	—	—	—	—	—
	KD_5	—	—	—	—	—	—	—	—	—	—
Recess											
Dimensions	R × R	220	270	270	330	330	360	360	395	395	395
	Q	120	120	120	120	120	120	120	120	120	120

Dimensions in mm



LMK Post Tensioning System	**LMK External Post-Tensioning System with 2 to 37 strands** Anchorage – Minimum concrete strength, additional reinforcement, details on dimensions	**Annex 9** of European Technical Assessment **ETA-24/0184** of 19.04.2024

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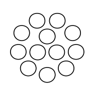
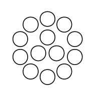
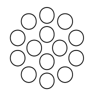
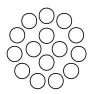
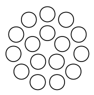
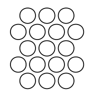
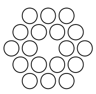
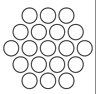
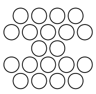
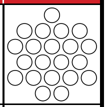
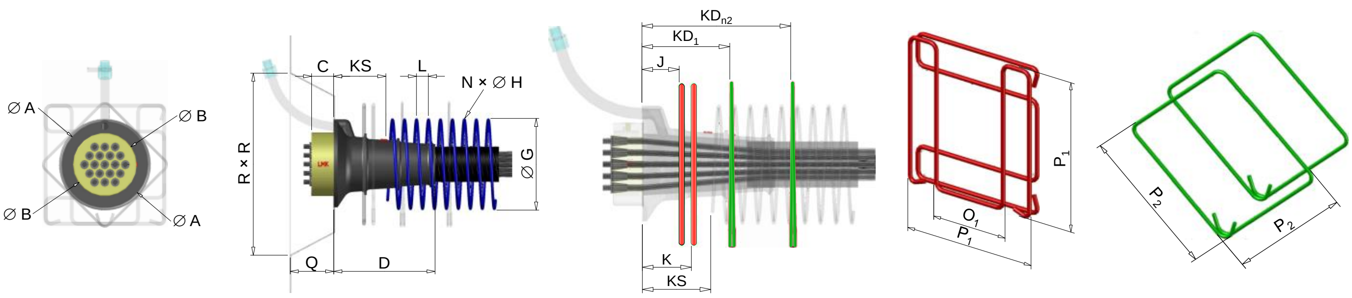
Table 10: Anchorage – Minimum concrete strength, additional reinforcement, details on dimensions

Anchorage		LMK-S-DE-M-15 and LMK-F-DE-M-15									
Number of strands	DE	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
Strand arrangement											
Bearing plate	∅ A	225	255	255	255	280	280	280	280	310	310
	D	230	250	250	250	325	325	325	325	325	325
Anchor head	∅ B	166	178	178	178	206	206	206	206	226	226
	C	63	63	65	68	70	73	75	75	80	80
Minimum concrete strength at time of stressing, cube											
Minimum concrete strength in MPa	$f_{cm,0}$	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**
Helix											
External diameter	∅ G	370	400	400	400	450	450	450	450	460	460
Number of turns	N	9	10	10	10	11	11	11	11	12	12
Wire diameter	∅ H	12	14	14	14	14	14	14	14	16	16
Dimension	L	60	60	60	60	60	60	60	60	60	60
Distance	KS	20	20	20	20	30	30	30	30	30	30
W stirrups											
Dimensions	P_1	380	425	425	425	500	500	500	500	540	540
	O_1	195	205	205	205	215	215	215	215	255	255
	∅ S_{1d}	14	14	14	14	14	14	14	14	16	16
Number of layers	n1	2	2	2	2	2	2	2	2	2	2
Distance	J	70	70	70	70	70	70	70	70	70	70
	K	110	110	110	110	110	110	110	110	120	120
Square stirrups											
Dimensions	P_2	390	430	430	430	480	480	480	480	500	500
	∅ S_{2d}	8	10	10	10	10	10	10	10	10	10
Number of layers	n2	3	4	4	4	4	4	4	4	4	4
Distance	KD_1	170	170	170	170	170	170	170	170	180	180
	KD_2	320	320	320	320	320	320	320	320	330	330
	KD_3	470	470	470	470	470	470	470	470	480	480
	KD_4	—	620	620	620	620	620	620	620	630	630
	KD_5	—	—	—	—	—	—	—	—	—	—
Recess											
Dimensions	R × R	420	420	470	470	485	485	500	500	500	545
	Q	130	130	130	140	140	140	140	140	150	150

Dimensions in mm



LMK Post Tensioning System	**LMK External Post-Tensioning System with 2 to 37 strands** Anchorage – Minimum concrete strength, additional reinforcement, details on dimensions	**Annex 10** of European Technical Assessment **ETA-24/0184** of 19.04.2024

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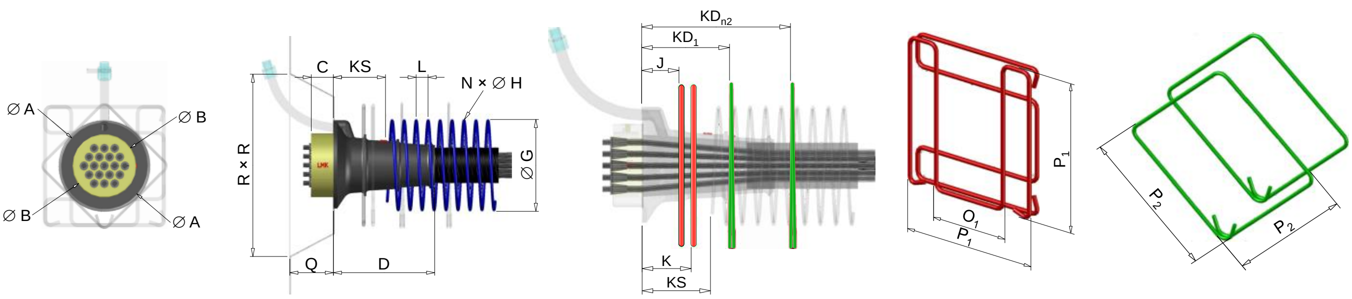
Table 11: Anchorage – Minimum concrete strength, additional reinforcement, details on dimensions

Anchorage		LMK-S-$_{DE}$-M-15 and LMK-F-$_{DE}$-M-15									
Number of strands	DE	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**
Strand arrangement											
Bearing plate	∅ A	310	340	340	340	340	340	360	360	360	360
	D	325	385	385	385	385	385	440	440	440	440
Anchor head	∅ B	226	244	244	244	244	244	260	260	260	260
	C	80	82	82	85	85	85	88	88	90	90
Minimum concrete strength at time of stressing, cube											
Minimum concrete strength in MPa	$f_{cm,0}$	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**
Helix											
External diameter	∅ G	460	480	480	480	480	480	500	500	500	500
Number of turns	N	12	13	13	13	13	13	14	14	14	14
Wire diameter	∅ H	16	16	16	16	16	16	16	16	16	16
Dimension	L	60	60	60	60	60	60	60	60	60	60
Distance	KS	30	40	40	40	40	40	40	40	40	40
W stirrups											
Dimensions	P_1	540	570	570	570	570	570	635	635	635	635
	O_1	255	275	275	275	275	275	315	315	315	315
	∅ S_{1d}	16	16	16	16	16	16	18	18	18	18
Number of layers	n1	2	2	2	2	2	2	2	2	2	2
Distance	J	70	75	75	75	75	75	75	75	75	75
	K	120	125	125	125	125	125	125	125	125	125
Square stirrups											
Dimensions	P_2	500	530	530	530	530	530	540	540	540	540
	∅ S_{2d}	10	12	12	12	12	12	14	14	14	14
Number of layers	n2	4	5	5	5	5	5	5	5	5	5
Distance	KD_1	180	190	190	190	190	190	190	190	190	190
	KD_2	330	340	340	340	340	340	340	340	340	340
	KD_3	480	490	490	490	490	490	490	490	490	490
	KD_4	630	640	640	640	640	640	640	640	640	640
	KD_5	—	790	790	790	790	790	790	790	790	790
Recess											
Dimensions	R × R	545	575	575	575	575	620	620	620	630	630
	Q	150	150	150	150	150	150	150	150	150	150

Dimensions in mm



Post Tensioning System

LMK External Post-Tensioning System with 2 to 37 strands

Anchorage – Minimum concrete strength, additional reinforcement, details on dimensions

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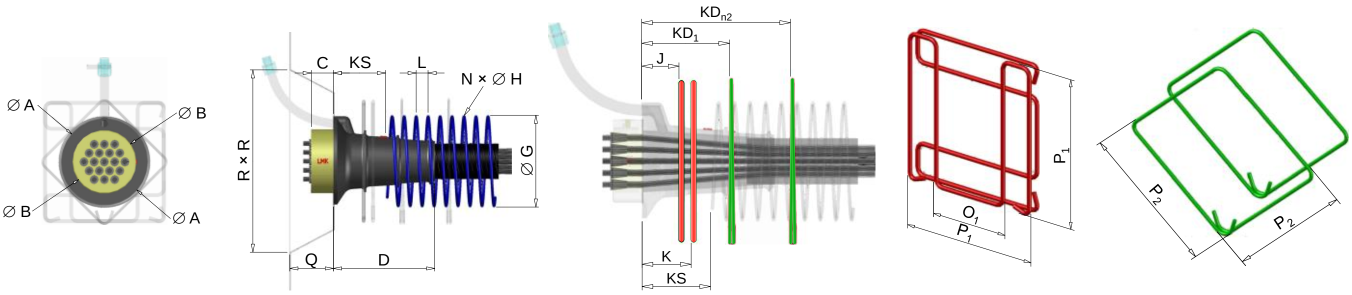
Table 12: Anchorage – Minimum concrete strength, additional reinforcement, details on dimensions

Anchorage		LMK-S-DE-M-15 and LMK-F-DE-M-15					
Number of strands	DE	**32**	**33**	**34**	**35**	**36**	**37**
Strand arrangement							
Bearing plate	∅ A	405	405	405	405	405	405
	D	500	500	500	500	500	500
Anchor head	∅ B	296	296	296	296	296	296
	C	95	95	95	100	100	100
Minimum concrete strength at time of stressing, cube							
Minimum concrete strength in MPa	$f_{cm,0}$	**40**	**40**	**40**	**40**	**40**	**40**
Helix							
External diameter	∅ G	520	520	520	520	520	520
Number of turns	N	15	15	15	15	15	15
Wire diameter	∅ H	18	18	18	18	18	18
Dimension	L	60	60	60	60	60	60
Distance	KS	45	45	45	45	45	45
W Stirrups							
Dimensions	P_1	680	680	680	680	680	680
	O_1	350	350	350	350	350	350
	∅ S_{1d}	20	20	20	20	20	20
Number of layers	n1	2	2	2	2	2	2
Distance	J	75	75	75	75	75	75
	K	125	125	125	125	125	125
Square stirrups							
Dimensions	P_2	600	600	600	600	600	600
	∅ S_{2d}	14	14	14	14	14	14
Number of layers	n2	5	5	5	5	5	5
Distance	KD_1	195	195	195	195	195	195
	KD_2	345	345	345	345	345	345
	KD_3	495	495	495	495	495	495
	KD_4	645	645	645	645	645	645
	KD_5	795	795	795	795	795	795
Recess							
Dimensions	R × R	700	700	700	700	700	700
	Q	170	170	170	170	170	170

Dimensions in mm



LMK Post Tensioning System

LMK External Post-Tensioning System with 2 to 37 strands

Anchorage – Minimum concrete strength, additional reinforcement, details on dimensions

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Table 13: Tendons

Tendon			Characteristic tensile strength
			1 860 MPa
Number of strands	Nominal cross-sectional area	Nominal mass of prestressing steel	Characteristic value of maximum tendon force
DE	A_p	M	F_{pk}
—	mm^2	kg / m	kN
2	300	2.34	558
3	450	3.52	837
4	600	4.69	1 116
5	750	5.86	1 395
6	900	7.03	1 674
7	1 050	8.20	1 953
8	1 200	9.38	2 232
9	1 350	10.55	2 511
10	1 500	11.72	2 790
11	1 650	12.89	3 069
12	1 800	14.06	3 348
13	1 950	15.24	3 627
14	2 100	16.41	3 906
15	2 250	17.58	4 185
16	2 400	18.75	4 464
17	2 550	19.92	4 743
18	2 700	21.10	5 022
19	2 850	22.27	5 301
20	3 000	23.44	5 580
21	3 150	24.61	5 859
22	3 300	25.78	6 138
23	3 450	26.96	6 417
24	3 600	28.13	6 696
25	3 750	29.30	6 975
26	3 900	30.47	7 254
27	4 050	31.64	7 533
28	4 200	32.82	7 812
29	4 350	33.99	8 091
30	4 500	35.16	8 370
31	4 650	36.33	8 649
32	4 800	37.50	8 928
33	4 950	38.68	9 207
34	5 100	39.85	9 486
35	5 250	41.02	9 765
36	5 400	42.19	10 044
37	5 550	43.36	10 323

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Table 14: Maximum prestressing and overstressing forces of a single prestressing steel strand

Nominal diameter	Nominal cross-sectional area	Characteristic value of maximum force	Force at 0.1 % proof stress	Maximum prestressing force [1]	Maximum overstressing force [1), 2]
d	A_p	F_{pk}	$F_{p0.1}$	$0.9 \cdot F_{p0.1}$	$0.95 \cdot F_{p0.1}$
mm	mm²	kN	kN	kN	kN
Characteristic tensile strength f_{pk} = 1 860 MPa					
15.7	150	279	246	221	234

1) The maximum prestressing and overstressing forces are maximum values according to Eurocode 2, i.e. $\min(k_1 \cdot f_{pk}, k_2 \cdot f_{p0.1})$ applies, and to prEN 10138-3. Fulfilment of stabilisation criteria and requirements for crack widths in load transfer tests was verified at $0.8 \cdot F_{pk}$.
However, maximum prestressing and overstressing forces according to the standards and regulations in force at the place of use are observed.

2) Overstressing up to the maximum overstressing forces is permitted if the force in the prestressing jack can be measured to an accuracy of ± 5 % of the final value of the overstressing force.

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Table 15: Maximum prestressing and overstressing forces of a tendon with prestressing steel strands of 150 mm² nominal cross-sectional area and 1 860 MPa characteristic tensile strength

Number of strands	Nominal cross-sectional area of tendon	Characteristic value of maximum tendon force	Maximum prestressing force of tendon [1)]	Maximum overstressing force of tendon [1), 2)]
DE	A_p	F_{pk}	$0.9 \cdot F_{p0.1}$	$0.95 \cdot F_{p0.1}$
—	mm²	kN	kN	kN
2	300	558	443	467
3	450	837	664	701
4	600	1 116	886	935
5	750	1 395	1 107	1 169
6	900	1 674	1 328	1 402
7	1 050	1 953	1 550	1 636
8	1 200	2 232	1 771	1 870
9	1 350	2 511	1 993	2 103
10	1 500	2 790	2 214	2 337
11	1 650	3 069	2 435	2 571
12	1 800	3 348	2 657	2 804
13	1 950	3 627	2 878	3 038
14	2 100	3 906	3 100	3 272
15	2 250	4 185	3 321	3 506
16	2 400	4 464	3 542	3 739
17	2 550	4 743	3 764	3 973
18	2 700	5 022	3 985	4 207
19	2 850	5 301	4 207	4 440
20	3 000	5 580	4 428	4 674
21	3 150	5 859	4 649	4 908
22	3 300	6 138	4 871	5 141
23	3 450	6 417	5 092	5 375
24	3 600	6 696	5 314	5 609
25	3 750	6 975	5 535	5 843
26	3 900	7 254	5 756	6 076
27	4 050	7 533	5 978	6 310
28	4 200	7 812	6 199	6 544
29	4 350	8 091	6 421	6 777
30	4 500	8 370	6 642	7 011
31	4 650	8 649	6 863	7 245
32	4 800	8 928	7 085	7 478
33	4 950	9 207	7 306	7 712
34	5 100	9 486	7 528	7 946
35	5 250	9 765	7 749	8 180
36	5 400	10 044	7 970	8 413
37	5 550	10 323	8 192	8 647

For footnotes [1)] and [2)] see Annex 14.

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Table 16: Material specifications

Component	Standard or Specification
Anchor head	EN ISO 683-2
Bearing plate	EN 1563
Wedge	EN ISO 683-3
Helix Additional stirrup reinforcement	Ribbed reinforcing steel, $R_e \geq 500$ MPa
Smooth PE duct	EN 12201-1, EN 12201-2

Table 17: Prestressing steel strands according to prEN 10138-3 [1)]

Steel name			Y1860S7
Tensile strength	f_{pk}	MPa	1 860
Nominal diameter	d	mm	15.7
Nominal cross-sectional area	A_p	mm^2	150
Individual Wire			
External wire diameter	d	mm	~ 5.2 ± 0.04
Core wire diameter	d'	mm	≥ 1.03 · d
Prestressing steel strand			
Mass per metre	M	kg/m	1.172
Allowable deviation from nominal mass		%	± 2
Characteristic value of maximum force	F_{pk}	kN	279
Maximum value of maximum force	$F_{m, ma}$	kN	321
Characteristic value of 0.1 % proof force	$F_{p0.1}$	kN	246
Minimum elongation at maximum force, $L_0 \geq 500$ mm	A_{gt}	%	3.5
Modulus of Elasticity	E_p	MPa	195 000 [2)]

1) Prestressing steel strands according to prEN 10138-3 and other suitable prestressing steel strands according to standards and regulations in force at the place of use may also be used.
2) Standard value

Table 18: Contents of the prescribed test plan

<table>
<tr><th colspan="2">Subject / type of control</th><th>Test or control method</th><th>Criteria, if any</th><th>Minimum number of samples</th><th>Minimum frequency of control</th></tr>
<tr><td rowspan="4">Anchor head</td><td>Material</td><td>Checking [1]</td><td>[2]</td><td>100 %</td><td>continuous</td></tr>
<tr><td>Detailed dimensions</td><td>Testing</td><td>[2]</td><td>5%,
≥ 2 specimens</td><td>continuous</td></tr>
<tr><td>Visual inspection [3]</td><td>Checking</td><td>[2]</td><td>100 %</td><td>continuous</td></tr>
<tr><td>Traceability</td><td colspan="4">full</td></tr>
<tr><td rowspan="5">Wedge</td><td>Material</td><td>Checking [1]</td><td>[2]</td><td>100 %</td><td>continuous</td></tr>
<tr><td>Treatment, hardness</td><td>Testing</td><td>[2]</td><td>0.5 %,
≥ 2 specimens</td><td>continuous</td></tr>
<tr><td>Detailed dimensions</td><td>Testing</td><td>[2]</td><td>5 %,
≥ 2 specimens</td><td>continuous</td></tr>
<tr><td>Visual inspection [3]</td><td>Checking</td><td>[2]</td><td>100 %</td><td>continuous</td></tr>
<tr><td>Traceability</td><td colspan="4">full</td></tr>
<tr><td rowspan="4">Bearing plate</td><td>Material</td><td>Checking [1]</td><td>[2]</td><td>100 %</td><td>continuous</td></tr>
<tr><td>Detailed dimensions</td><td>Testing</td><td>[2]</td><td>3 %,
≥ 2 specimens</td><td>continuous</td></tr>
<tr><td>Visual inspection [3]</td><td>Checking</td><td>[2]</td><td>100 %</td><td>continuous</td></tr>
<tr><td>Traceability</td><td colspan="4">bulk</td></tr>
<tr><td rowspan="3">Prestressing steel strand</td><td>Material</td><td>Checking</td><td>[2), 4)]</td><td>100 %</td><td>continuous</td></tr>
<tr><td>Diameter</td><td>Testing</td><td>[2]</td><td>1 sample</td><td rowspan="2">each coil or every 7 tons [5]</td></tr>
<tr><td>Visual inspection</td><td>Checking</td><td>[2]</td><td>1 sample</td></tr>
<tr><td rowspan="3">Steel strip sheath</td><td>Material</td><td>Checking [6]</td><td>[2]</td><td>100 %</td><td>continuous</td></tr>
<tr><td>Dimension</td><td>Testing</td><td>[2]</td><td>3 %,
≥ 2 specimens</td><td>continuous</td></tr>
<tr><td>Traceability</td><td colspan="4">full</td></tr>
<tr><td rowspan="4">Filling materials as per EN 447</td><td>Constituent</td><td>Checking [6]</td><td>[2]</td><td>100 %</td><td>continuous</td></tr>
<tr><td>Cement</td><td>Checking [6]</td><td>[2]</td><td>100 %</td><td>continuous</td></tr>
<tr><td>Admixtures, additions</td><td>Checking [6]</td><td>[2]</td><td>100 %</td><td>continuous</td></tr>
<tr><td>Traceability</td><td colspan="4">full</td></tr>
</table>

1) Checking by means of an inspection certificate 3.1 according to EN 10204.
2) Conformity with the specifications of the components
3) Successful visual inspection does not need to be documented.
4) Checking of relevant certificate, as long as the basis of "CE"-marking is not available.
5) Maximum between a coil and 7 tons is taken into account.
6) Checking of relevant certificate, CE marking and declaration of performance or, if basis for CE marking is not available, certificate of supplier

Traceability ...... full........... Full traceability of each component to its raw material.
bulk......... Traceability of each delivery of components to a defined point.
Material............................ Defined according to technical specification deposited by the supplier
Detailed dimension........... Measuring of all the dimensions and angles according to the specification given in the test plan
Visual inspection .... Main dimensions, correct marking and labelling, surface, corrosion, coating, etc.
Treatment, hardness .... Surface hardness, core hardness, and treatment depth

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Table 19: Audit testing

Subject / type of control		Test or control method	Criteria, if any	Minimum number of samples 1)	Minimum frequency of control
Anchor head	Material	Checking and testing, hardness and chemical 2)	3)	1	1/year
	Detailed dimensions	Testing	3)	1	1/year
	Visual inspection	Checking	3)	1	1/year
Wedge	Material	Checking and testing, hardness and chemical 2)	3)	2	1/year
	Treatment, hardness	Checking and testing, hardness profile	3)	2	1/year
	Detailed dimensions	Testing	3)	1	1/year
	Main dimensions, surface hardness	Testing	3)	5	1/year
	Visual inspection	Checking	3)	5	1/year
Bearing plate	Material	Checking and testing, hardness and chemical 2)	3)	1	1/year
	Detailed dimensions	Testing	3)	1	1/year
	Visual inspection	Checking	3)	1	1/year
Single tensile element test		According to EAD 160004-00-0301, Annex C.7		9	1/year

1) If the kits comprise different kinds of anchor heads e.g. with different materials, different shape, different wedges, etc., then the number of samples is understood as per kind.

2) Testing of hardness and checking of chemical composition by means of an inspection certificate 3.1 according to EN 10204.

3) Conformity with the specifications of the components

Material .... Defined according to technical specification deposited by the ETA holder at the Notified body

Detailed dimension .... Measuring of all the dimensions and angles according to the specification given in the test plan

Visual inspection............. Main dimensions, correct marking and labelling, surface, corrosion, coating, etc.

Treatment, hardness ...... Surface hardness, core hardness, and treatment depth

LMK Post Tensioning System	**LMK External Post-Tensioning System with 2 to 37 strands** Audit testing	**Annex 19** of European Technical Assessment **ETA-24/0184** of 19.04.2024

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Reference documents

European Assessment Documents

EAD 160004-00-0301	Post-Tensioning Kits for Prestressing of Structures
EAD 160027-00-0301	Special filling Products for Post-Tensioning Kits

Eurocode

Eurocode 2	Eurocode 2 – Design of concrete structures
Eurocode 3	Eurocode 3 – Design of steel structures
Eurocode 6	Eurocode 6 – Design of masonry structures

Standards

EN 206+A1 (03.2021)	Concrete – Specification, performance, production and conformity
EN 447 (10.2007)	Grout for prestressing tendons – Basic requirements
EN 1563 (08.2018)	Founding – Spheroidal graphite cast irons
EN 10204 (10.2004)	Metallic products – Types of inspection documents
EN 10216-1 (12.2013)	Seamless steel tubes for pressure purposes – Technical delivery conditions – Part 1: Non-alloy steel tubes with specified room temperature properties
EN 10217-1 (04.2019)	Welded steel tubes for pressure purposes – Technical delivery conditions – Part 1: Electric welded and submerged arc welded non-alloy steel tubes with specified room temperature properties
EN 10219-1 (04.2006)	Cold formed welded structural hollow sections of non-alloy and fine grain steels – Part 1: Technical delivery conditions
EN 10255+A1 (04.2007)	Non-Alloy steel tubes suitable for welding and threading – Technical delivery conditions
EN 10305-3 (12.2023)	Steel tubes for precision applications – Technical delivery conditions – Part 3: Welded cold sized tubes
EN 12201-1 (01.2024)	Plastics piping systems for water supply, and for drains and sewers under pressure – Polyethylene (PE) – Part 1: General
EN 12201-2 (01.2024)	Plastics piping systems for water supply, and for drains and sewers under pressure – Polyethylene (PE) – Part 2: Pipes
EN 13670 (12.2009)	Execution of concrete structures
prEN 10138-3 (08.2009)	Prestressing steels – Part 3: Strand
EN ISO 683-2 (06.2018)	Heat-treatable steels, alloy steels and free-cutting steels – Part 2: Alloy steels for quenching and tempering
EN ISO 683-3 (02.2022)	Heat-treatable steels, alloy steels and free-cutting steels – Part 3: Case-hardening steels
EN ISO 12944-5 (10.2019)	Paints and varnishes – Corrosion protection of steel structures by protective paint systems – Part 5: Protective paint systems

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98/456/EC	Commission Decision 98/456/EC of 3 July 1998 on the procedure for attesting the conformity of construction products pursuant to Article 20(2) of Council Directive 89/106/EEC as regards post-tensioning kits for the prestressing of structures, Official Journal L 201 of 17 July 1998, page 112
305/2011	Regulation (EU) № 305/2011 of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC, OJ L 88 of 4 April 2011, p. 5, amended by Commission Delegated Regulation (EU) № 568/2014 of 18 February 2014, OJ L 157 of 27.05.2014, p. 76, Commission Delegated Regulation (EU) № 574/2014 of 21 February 2014, OJ L 159 of 28.05.2014, p. 41, and Regulation (EU) 2019/1020 of the European Parliament and of the Council of 20 June 2019, OJ L 169 of 15.06.2019, p. 1
568/2014	Commission Delegated Regulation (EU) № 568/2014 of 18 February 2014 amending Annex V to Regulation (EU) № 305/2011 of the European Parliament and of the Council as regards the assessment and verification of constancy of performance of construction products, OJ L 157 of 27 May 2014, page 76

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