

European Technical Assessment

ETA 07/0035
of 01/12/2021

**Technical Assessment Body
issuing the ETA:**

Cerema
Direction technique infrastructures de transport et
matériaux

Trade name of the construction product

CCL 'XM' Multistrand Bonded/Unbonded System
CCL 'XMC' Multistrand Bonded System

**Product family to which the construction
product belongs**

16. Reinforcing and prestressing steel for concrete
(and ancillaries). Post tensioning kits.

Manufacturer

CCL Stressing International Ltd
Unit 8 Park 2000 Millennium Drive
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LS11 5BP

Manufacturing plant(s)

CCL Stressing Systems Ltd
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**This European Technical Assessment
contains**

68 pages including 40 Annexes (40 pages) which
form an integral part of this assessment.

**This European Technical Assessment is
issued in accordance with regulation (EU)
No 305/2011, on the basis of**

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EXTRACT OF CCL ETA-07/0035

The attached pages will focus on 15.7mm/1860 MPa strands -
commonly used in Scandinavia.

For further information please contact CCL/Skandinavisk Spaendbeton.

1. Technical description of the products

1.1. Definition of the product

This European Technical Assessment applies to:

1.1.1. CCL 'XM' Multistrand Bonded/Unbonded Post-Tensioning System

Consisting of the following components:

- Tendon:

Bonded/Unbonded multistrand tendons with 3-55 tensile elements

- Tensile Elements:

7-wire prestressing steel strand with nominal tensile strengths of 1770 MPa/1860 MPa and nominal diameters of 12.5 mm / 12.9 mm / 13.0 mm / 15.2 mm / 15.3 mm / 15.7 mm

- Anchorages:

Live End and Dead End anchorages with 3-55 strands

Threaded Anchor Head Live End anchorages with 3-22 strands

- Reinforcement:

Local anchorage zone reinforcement in Helix and Link layouts

- Corrosion Protection:

Grout/Grease/Wax & sealing around the anchorage zone & duct

1.1.2. CCL 'XMC' Multistrand Coupler Bonded Post-Tensioning System

Consisting of the following components:

- Tendon:

Bonded tendons with 3-37 tensile elements

- Tensile Elements:

7-wire prestressing steel strand with nominal tensile strengths of 1770 MPa/1860 MPa and nominal diameters of 15.2 mm / 15.3 mm / 15.7 mm

- Anchorages:

Live End and Dead End anchorages with 3-37 strands

- Reinforcement:

Local anchorage zone reinforcement in Helix and Link layouts

- Corrosion Protection:

Grout and sealing around the anchorage zone & duct

1.2. Components and design

1.2.1. Range and Designation of Anchorages

The type of anchorage is designated depending on its function in the structure in the following order:

- The first letters signify the System Type;
- The next numbers signify the size of the Force Transfer Unit;
- The next numbers signify the maximum number of strands in the tendon;
- The next numbers signify the nominal diameter of the strands in the tendon;
- The next letter shows the type of anchorage.
- The optional last letter (only for XM systems) signifies whether the system is encapsulated.

Examples:

XM-60-19-15.7-L-E:

Encapsulated Live End multistrand anchorage with a size 60 Force Transfer Unit having 19 strands of Ø15.7 mm.

XM-40-18-12.9-D:

Dead End multistrand anchorage with a size 40 Force Transfer Unit having 18 strands of Ø12.9 mm.

XMC-60-19-15.2-L:

Live End multistrand coupler anchorage with a size 60 Force Transfer Unit having 19 strands of Ø15.2 mm.

XMC-40-12-15.7-D:

Dead End multistrand coupler anchorage with a size 40 Force Transfer Unit having 12 strands of Ø15.7mm.

XM-60-19-15.7-TAH:

Threaded Anchor Head Live End multistrand anchorage with a size 60 Force Transfer Unit having 19 strands of Ø15.7 mm.

The various types of anchorage are specified in Tables 1, 2 and 3.

Table 1 CCL 'XM' Anchorages for 15 mm Systems

Anchorage	No. of Strands	Strand Ø
XM-10	3	15.2/15.3/15.7
XM-20	4	15.2/15.3/15.7
XM-30	7	15.2/15.3/15.7
XM-35	9	15.2/15.3/15.7
XM-40	12	15.2/15.3/15.7
XM-45	13	15.2/15.3/15.7
XM-50	15	15.2/15.3/15.7
XM-55	17	15.2/15.3/15.7
XM-60	19	15.2/15.3/15.7
XM-70	22	15.2/15.3/15.7
XM-75	25	15.2/15.3/15.7
XM-80	27	15.2/15.3/15.7
XM-90	31	15.2/15.3/15.7
XM-95	35	15.2/15.3/15.7
XM-100	37	15.2/15.3/15.7

Table 2 CCL 'XM' Anchorages for 13 mm Systems

Anchorage	No. of Strands	Strand Ø
XM-10	4	12.5/12.9/13.0
XM-20	6	12.5/12.9/13.0
XM-30	9	12.5/12.9/13.0
XM-35	12	12.5/12.9/13.0
XM-40	18	12.5/12.9/13.0
XM-45	19	12.5/12.9/13.0
XM-50	22	12.5/12.9/13.0
XM-55	25	12.5/12.9/13.0
XM-60	27	12.5/12.9/13.0
XM-70	31	12.5/12.9/13.0
XM-75	37	12.5/12.9/13.0
XM-80	40	12.5/12.9/13.0
XM-90	46	12.5/12.9/13.0
XM-95	51	12.5/12.9/13.0
XM-100	55	12.5/12.9/13.0

Table 3 CCL 'XMC' Anchorages for 15 mm Systems

Anchorage	No. of Strands	Strand Ø
XMC-10	3	15.2/15.3/15.7
XMC-20	4	15.2/15.3/15.7
XMC-30	7	15.2/15.3/15.7
XMC-35	9	15.2/15.3/15.7
XMC-40	12	15.2/15.3/15.7
XMC-45	13	15.2/15.3/15.7
XMC-50	15	15.2/15.3/15.7
XMC-55	17	15.2/15.3/15.7
XMC-60	19	15.2/15.3/15.7
XMC-70	22	15.2/15.3/15.7
XMC-75	25	15.2/15.3/15.7
XMC-80	27	15.2/15.3/15.7
XMC-90	31	15.2/15.3/15.7
XMC-95	35	15.2/15.3/15.7
XMC-100	37	15.2/15.3/15.7

For better utilisation of the prestressing force within the structure, it is possible to use CCL 'XM' and 'XMC' anchorages with a number of strands lower than the maximum number specified. In this case, intermediate units can be modified from the existing designs provided strands lie symmetrically around the anchor head to ensure the force is safely aligned.

1.2.1.1 'XM' Live End Anchorages

CCL 'XM' Live End (LE) Anchorages are circular section multistrand anchorages shown in Annexes 2 & 4. The anchorage comprises:

- Steel Wedges
- Steel Anchor Head (AH)
- Cast Iron Force Transfer Unit (FTU)
- Plastic Deviation Cone (DC)

The strands of the anchorage are simultaneously stressed by a Jack bearing on the FTU by means of a Bearing Ring (BR).

The prestressing force is applied to the strands and locked in place by the wedges into the AH which is supported on the FTU cast into the concrete. This FTU ensures the transmission of the prestressing force into the concrete.

The FTU and the DC ensure the correct deviation of the strands from the AH to the Duct.

LE anchorages can be used as Active or Passive anchorages.

1.2.1.2 **‘XM’ Dead End Anchorages**

CCL ‘XM’ Dead End (DE) Anchorages are circular section multistrand anchorages shown in Annexes 3 & 5. The anchorage comprises:

- Steel Wedges
- Steel Anchor Head
- Cast Iron Force Transfer Unit
- Plastic Deviation Cone
- Spring Loaded Spring Plate (SP) and Fixings

The wedges are locked in place with the SP while the prestressing force is applied to the opposite (live) end of the tendon. The prestressing force in the strands is locked by the wedges into the AH which is supported on the FTU cast into the concrete. This FTU ensures the transmission of the prestressing force to the concrete.

The FTU and the DC ensure the correct deviation of the strands from the AH to the Duct.

No Jacking is required at this end of the anchorage.

DE anchorages can be used as Passive anchorages only.

If required by a specific project, DE anchorages can be used as buried passive anchorages with the provision of a sealing cap and a suitable grout vent. Threading of strands must be completed before concreting. CCL must be consulted before the use of a buried DE anchorage.

1.2.1.3 **‘XM’ Encapsulated Live End Anchorages**

CCL ‘XM’ Encapsulated Live End (ELE) Anchorages are circular section multistrand anchorages shown in Annex 6. The anchorage comprises:

- Steel Wedges
- Steel Anchor Head (AH)
- Cast Iron Force Transfer Unit (FTU)
- Plastic Deviation Cone (DC)
- Plastic Sealing Cap (SC)
- Connecting Accessories

The strands of the anchorage are simultaneously stressed by a Jack bearing on the FTU by means of a Bearing Ring (BR).

The prestressing force is applied to the strands and locked in place by the wedges into the AH which is supported on the FTU cast into the concrete. This FTU ensures the transmission of the prestressing force into the concrete.

The FTU and the DC ensure the correct deviation of the strands from the AH to the Duct.

LE anchorages can be used as Active or Passive anchorages.

1.2.1.4 **‘XM’ Encapsulated Dead End Anchorages**

CCL ‘XM’ Encapsulated Dead End Anchorages (EDE) are circular section multistrand anchorages shown in Annex 7. The anchorage comprises:

- Steel Wedges
- Steel Anchor Head
- Cast Iron Force Transfer Unit
- Plastic Deviation Cone
- Spring Loaded Spring Plate (SP) and Fixings
- Plastic Sealing Cap (SC)
- Connecting Accessories

The wedges are locked in place with the SP while the prestressing force is applied to the opposite (live) end of the tendon. The prestressing force in the strands is locked by the wedges into the AH which is supported on the FTU cast into the concrete. This FTU ensures the transmission of the prestressing force to the concrete.

The FTU and the DC ensure the correct deviation of the strands from the AH to the Duct.

No Jacking is required at this end of the anchorage.

DE anchorages can be used as Passive anchorages only.

If required by a specific project, EDE anchorages can be used as buried passive anchorages with the provision a suitable grout vent linked to the SC. Threading of strands must be completed before concreting. CCL must be consulted before the use of a buried EDE anchorage.

1.2.1.5 **‘XMC’ Live End Coupler Anchorages**

CCL ‘XMC’ Live End (LE) Anchorages are circular section multistrand anchorages shown in Annex 8.

The anchorage comprises:

- Steel Wedges
- Steel Coupler (C)
- Cast Iron Force Transfer Unit (FTU)
- Plastic Deviation Cone (DC)
- SG Iron Coupler Extension Ring (CER)
- Steel Coupler Reducing Cone Retainer (CRCR)
- Plastic Coupler Reducing Cone (CRC)
- Spring Loaded Coupler Outer Spring Plate (COSP) and Fixings

The 1st stage strands of the anchorage are simultaneously stressed by a Jack bearing on the Coupler by means of a Bearing Ring (BR).

The prestressing force is applied to the strands and locked in place by the wedges into the Coupler which is supported on the CER which is in turn supported on the CRCR and FTU which is cast into the concrete. This FTU ensures the transmission of the prestressing force into the concrete.

The FTU and the DC ensure the correct deviation of the 1st stage strands from the Coupler to the Duct.

The 2nd stage strands are positioned through the outer holes of the Coupler and are locked in place by the wedges and COSP. The CRC is positioned over the 2nd stage strands and Coupler and is

locked in place by the CRCR. The prestressing force is applied to the opposite (live) end of the tendon. The prestressing force in the strands is locked by the wedges into the Coupler. When cast into the concrete, the CRC ensures the correct deviation of the 2nd stage strands from the Coupler to the Duct.

1.2.1.6 **‘XMC’ Dead End Coupler Anchorages**

CCL ‘XMC’ Dead End (DE) Anchorages are circular section multistrand anchorages shown in Annex 9. The anchorage comprises:

- Steel Wedges
- Steel Coupler (C)
- Cast Iron Force Transfer Unit (FTU)
- Plastic Deviation Cone (DC)
- SG Iron Coupler Extension Ring (CER)
- Steel Coupler Reducing Cone Retainer (CRCR)
- Plastic Coupler Reducing Cone (CRC)
- Spring Loaded Coupler Outer Spring Plate and Fixings (COSP)
- Spring Loaded Spring Plate and Fixings (SP)

The 1st stage strands of the anchorage are locked in place with the SP while the prestressing force is applied to the opposite (live) end of the tendon. The prestressing force in the strands is locked by the wedges into the Coupler which is supported on the CER which is in turn supported on the CRCR and FTU which is cast into the concrete. This FTU ensures the transmission of the prestressing force into the concrete.

The FTU and the DC ensure the correct deviation of the 1st stage strands from the Coupler to the Duct.

The 2nd stage strands are positioned through the outer holes of the Coupler and are locked in place by the wedges and COSP. The CRC is positioned over the 2nd stage strands and Coupler and is locked in place by the CRCR. The prestressing force is applied to the opposite end of the tendon. The prestressing force in the strands is locked by the wedges into the Coupler. When cast into the concrete, the CRC ensures the correct deviation of the 2nd stage strands from the Coupler to the Duct.

No Jacking is required at this end of the anchorage.

DE anchorages can be used as Passive anchorages only.

1.2.1.7 **‘XM’ Threaded Anchor Head Live End Anchorages**

CCL ‘XM’ Thread Anchor Head (TAH) Live End Anchorages are circular section multistrand anchorages shown in Annexes 11. The anchorage comprises:

- Steel Wedges
- Steel Threaded Anchor Head (TAH)
- Cast Iron Force Transfer Unit (FTU)
- Plastic Deviation Cone (DC)

The strands of the anchorage are simultaneously stressed by a Jack bearing on the FTU by means of a Bearing Ring (BR).

The prestressing force is applied to the strands and locked in place by the wedges into the AH which is supported on the FTU cast into the concrete. This FTU ensures the transmission of the prestressing force into the concrete.

The FTU and the DC ensure the correct deviation of the strands from the AH to the Duct.

TAH anchorages are used as Active anchorages, for example as part of a ground anchorage according to EN 1537. The Threaded Anchor Head allows load monitoring of the anchor head after stressing via threaded sleeve / lift-off jack arrangement

1.2.2. Anchorage Components

1.2.2.1 Wedges Type 'X'

CCL Type 'X' wedges are manufactured from a suitable case-hardening steel to European Standard EN 10084 or BS 970.

The wedges are machined from bar stock according to the dimensions provided in Annex 12. Wedges are roll marked on their cylindrical face for identification purposes.

The wedges are then heat treated to a specific process to obtain the necessary hardness and ductility.

1.2.2.2 Anchor Heads

CCL 'XM' Anchor Heads are manufactured from a suitable steel to European Standard EN 10083.

The AHs are machined from cylindrical blanks made from steel bars according to the patterns provided in Annexes 13, 14, and 15. AHs are marked with the CCL Logo, TDC (Top Dead Centre), Part Number and Traceability Reference for identification purposes.

There are 3 types of Anchor Head:

- The Live End Anchor Head.
- The Dead End Anchor Head. This AH allows the fixing of a SP to ensure correct seating of the wedges during single end stressing.
- The Threaded Anchor Head. This TAH allows load monitoring of the anchor head after stressing via threaded sleeve / lift-off jack arrangement.

1.2.2.3 Force Transfer Units

CCL 'XM' Force Transfer Units are manufactured from a suitable cast iron to European Standard EN 1561.

The FTUs are cast; then the bearing face, grout entry connection and tapped holes for connection to the bearing ring/grout cap are machined according to the dimensions provided in Annex 17 FTUs are marked with the CCL Logo, Part Number and Traceability Reference for identification purposes.

CCL 'XM' FTUs have a circular bearing face (which supports the cylindrical AH) and multiple surfaces of load transfer for transmission of prestressing force from the tendon to the reinforced concrete that surrounds them. The FTU also supports the Jack during stressing via a Bearing Ring (BR). Filling material entry is through a tapped hole with parallel pipe thread EN 10226 Rp 3/4 (¾ BSP) to EN 10226-1 in the face of the casting. Venting may also take place through this connection when required. The opposite end of the casting is internally threaded for connection of the DC.

1.2.2.4 **Couplers**

CCL 'XMC' Couplers are manufactured from a suitable steel to European Standard EN 10083.

The Couplers are machined from cylindrical blanks made from steel bars according to the patterns provided in Annex 16. The hole patterns of the 1st stage tendon match that of the XM AHs. Couplers are marked with the CCL Logo, TDC (Top Dead Centre), Part Number and Traceability Reference for identification purposes.

The 1st stage of the Coupler can be used as a Dead End anchorage when fitted with an SP to ensure correct seating of the wedges during single end stressing.

1.2.2.5 **Coupler Extension Rings**

CCL 'XMC' Coupler Extension Rings are manufactured from a suitable SG cast iron to European Standard EN 1563.

The CERs are cast; then the load-bearing faces and holes are machined according to the dimensions provided in Annex 18. CERs are marked with the CCL Logo, Part Number and Traceability Reference for identification purposes.

CCL 'XMC' CERs have a recessed circular bearing face which supports the cylindrical Coupler and transfers the prestress force to the FTU via the CRCR.

1.2.2.6 **Deviation Cones, Coupler Reducing Cones, Sealing Caps and Ducts**

CCL 'XM' DCs are moulded plastic cones threaded onto CCL 'XM' FTUs. For Encapsulated tendons, the joint between the FTU and DC is sealed using a heat shrink sleeve. These cones provide the deviation point for the strands in the tendon. The duct is connected to the DC via a coupler sleeve fitted to the location lugs on the cone.

CCL 'XMC' CRCs are moulded plastic cones locked onto CCL 'XM' FTUs by CCL CRCRs. These cones provide the deviation point for the 2nd stage strands in the tendon. The duct is connected to the CRC via a coupler sleeve fitted to the location lugs on the cone.

CCL 'XM' SCs are moulded plastic caps fitted with an O-Ring to CCL 'XM' FTUs. These caps completely encapsulate both types of anchor head and provide an air-tight seal.

DCs and CRCs and SCs can be manufactured from HDPE or Polypropylene according to the dimensions provided in Annexes 19, 20 & 21 and are supplied in the colour black. They are marked with the CCL Logo, Part Number and Traceability Reference for identification purposes.

Details of the connection between DCs, CRCs and metal ducts are shown in Annex 22, connections between the DCs, CRCs and plastic ducts are shown in Annex 23. Ducts should comply with the following standards:

- Metal ducts – EN 523
- Smooth steel pipes – EN 10255
- Plastic ducts – EAD 160004-00-0301
- Plastic pipes – EAD 160004-00-0301

1.2.2.8 Spring Loaded Retaining Plates

CCL 'XM' SPs and 'XMC' COSPs are manufactured from steel according to the dimensions provided in Annexes 24 & 25 with hole patterns to match the AHs / 1st stage strand pattern of the Couplers and the 2nd stage hole patterns of the Couplers respectively. The SPs and COSPs are marked with the CCL Logo, TDC (Top Dead Centre), Part Number and Traceability Reference for identification purposes.

1.2.2.9 Coupler Reducing Cone Retaining Plates

CCL 'XMC' CRCRs are manufactured from steel according to the dimensions provided in Annex 26 with hole diameters to match the bores of the CERs and FTUs. The CRCRs are marked with the CCL Logo, TDC (Top Dead Centre), Part Number and Traceability Reference for identification purposes.

1.2.2.10 Bursting Reinforcement

For each unit of the CCL 'XM' and 'XMC' PT System three types of reinforcement can be employed:

- Helices
- Links
- A combination of Helices and Links*

As the bursting reinforcement cannot compensate for a local defect of filling of the concrete behind the anchorage, the designer of the structure will have to ensure that the density and the distribution of the reinforcement in the vicinity of the anchorages allows pouring and adequate compaction of the concrete whilst maintaining containment of the bursting forces.

If required, the local zone reinforcement specified in the ETA and confirmed in the load transfer test may be modified for a specific project design in accordance with national regulations and relevant approval of the local authority and of the ETA holder to provide equivalent performance.

The local anchorage zone bursting reinforcement design rules for the CCL 'XM' and 'XMC' PT System are based on a modified version of the equation proposed by Roberts¹.

The design rules were established on the assumption of a single anchorage in a concrete prism tested in axial compression, with side lengths a and b (where $a = b$) and specimen height equal to twice the side length. Testing was carried out with 2 mean compressive concrete strengths; $f_{cm,0}$ on cube = 30 MPa and 55 MPa for units XM10-100. Additional testing was carried out with 1 mean compressive concrete strength; $f_{cm,0}$ on cube = 46 MPa for units XM10-80.

A copy of the local anchorage zone bursting reinforcement design rules for the CCL 'XM' and 'XMC' PT System is available from CCL on request.

The minimum bursting reinforcement dimensions for concrete strengths; $f_{cm,0}$ on cube = 30 MPa and 55 MPa for units XM10-100 are shown in Annexes 28 to 32 and for $f_{cm,0}$ on cube = 46 MPa for units XM10-80 see Annexes 34 & 35.

*Not available for units XM10-80 with concrete strength $f_{cm,0}$ on cube = 46 MPa

¹ Roberts C., Behaviour and Design of the Local Anchorage Zone in Post-Tensioned Concrete. M.S. Thesis, University of Texas at Austin, May 1990

1.2.3. Tendons

1.2.3.1 Standard Notation

Table 4 lists the standard notation and its intended meaning used within this ETA.

Table 4 Standard Notation

Notation	Definition
d	Nominal Diameter of an individual strand / mm
f_{pk}	Characteristic Tensile Strength of the strand / MPa
n	Number of individual strands in the tendon
A_p	Nominal Cross-Sectional Area of the tendon / mm ²
A_s	Nominal Cross-Sectional Area of an individual strand / mm ²
F_{pk}	Characteristic Ultimate Resisting Force of the tendon / kN ($F_{pk} = A_p \times f_{pk}$)
$F_{p0.1k}$	Characteristic 0.1% Proof Force of the tendon / kN ($F_{p0.1k} = A_p \times f_{p0.1k}$)
F_{pks}	Characteristic Ultimate Resisting Force of an individual strand / kN ($F_{pks} = A_s \times f_{pk}$)
$F_{p0.1ks}$	Characteristic 0.1% Proof Force of an individual strand / kN
F_0	Min ($k_1 F_{pk}$; $k_2 F_{p0.1k}$) / kN
F_{0s}	Min ($k_1 F_{pks}$; $k_2 F_{p0.1ks}$) / kN
M_p	Nominal Mass per Metre of the tendon / kg/m
M_s	Nominal Mass per Metre of an individual strand / g/m

The maximum allowable stressing force that can be applied to the tendon immediately prior to lock-off must be determined in accordance with EN 1992-1.1, with values given in the relevant national annex for k_1 and k_2 . Values given in the tables below are indicative values respecting recommended values by EN 1992-1.1 for k_1 and k_2 . Overstressing is permitted if the force in the jack can be measured to an accuracy of $\pm 5\%$ of the final value of the prestressing force. In such cases the maximum prestressing force P_{max} may be increased to $k_3 F_{p0.1ks}$ with $k_3=0.95$.

1.2.3.2 Strand Designation

Strand designation is in accordance with European Standard White Draft prEN 10138-3:2006 "Prestressing Steels - Part 3: Strand". For example, prestressing steel strand with a nominal tensile strength of 1860 MPa, 7 wires and a nominal diameter of 15.7 mm is designated as "EN10138-3-Y1860S7-15.7". Prestressing steel strand with a nominal tensile strength of 1770 MPa, 7 wires and a nominal diameter of 12.9 mm is designated as "EN10138-3-Y1770S7-12.9". In the interest of simplicity and for the purpose of this document, the various classes of strand will be referred to as Y(nominal tensile strength)-(nominal diameter), e.g. Y1770-15.2, as the standard prEN 10138-3:2006 and number of wires in the strand remain constant.

1.2.3.3 Strand Characteristics

The tendons consist of 3-55 7-wire prestressing steel strands, factory-provided with a corrosion protection system with characteristics in accordance with prEN 10138-3:2006. Some typical characteristics are provided in Table 5 and Annex 1.

In the absence of European standards for prestressing steel, strands complying with national provisions and with the characteristics given in Table 5 and Annex 1 shall be used.

Table 5 Strand Characteristics

Designation	d mm	A_s mm ²	M_s g/m	f_{pk} MPa	F_{pks} kN	$F_{p0.1ks}$ kN	F_{0s} kN
Y1770-12.5	12.5	93	726	1770	165	145	131
Y1860-12.5	12.5	93	726	1860	173	152	137
Y1770-12.9	12.9	100	781	1770	177	156	140
Y1860-12.9	12.9	100	781	1860	186	164	148
Y1860-13.0	13.0	102	797	1860	190	167	150
Y1770-15.2	15.2	139	1086	1770	246	216	194
Y1860-15.2	15.2	139	1086	1860	259	228	205
Y1770-15.3	15.3	140	1093	1770	248	218	196
Y1860-15.3	15.3	140	1093	1860	260	229	206
Y1770-15.7	15.7	150	1172	1770	266	234	211
Y1860-15.7	15.7	150	1172	1860	279	246	221

1.2.3.4 Prestressing Forces

Tables 6 to 11 list the maximum allowable prestressing forces for all tendons specified in this ETA as a guide only in accordance with Eurocode 2, 5.10.2.1. For certain countries where national provisions are more restrictive, lower prestressing forces than specified below shall be applied. Allowable prestressing forces must be checked against relevant local standards.

Table 6 Maximum Allowable Stressing Force of Tendons with Ø12.5 mm Strand

Anchorage	n	A_p mm ²	M_p kg/m	Y1770-12.5		Y1860-12.5	
				F_{pk} kN	F_0 kN	F_{pk} kN	F_0 kN
XM-10	4	372	2.91	658	522	692	547
XM-20	6	558	4.36	988	783	1038	821
XM-30	9	837	6.54	1481	1175	1557	1231
XM-35	12	1116	8.72	1975	1566	2076	1642
XM-40	18	1674	13.07	2963	2349	3114	2462
XM-45	19	1767	13.80	3128	2480	3287	2599
XM-50	22	2046	15.98	3621	2871	3806	3010
XM-55	25	2325	18.16	4115	3263	4325	3420
XM-60	27	2511	19.61	4444	3524	4670	3694
XM-70	31	2883	22.52	5103	4046	5362	4241
XM-75	37	3441	26.87	6091	4829	6400	5062
XM-80	40	3720	29.05	6584	5220	6919	5472
XM-90	46	4278	33.41	7572	6003	7957	6293
XM-95	51	4743	37.04	8395	6656	8822	6977
XM-100	55	5115	39.95	9054	7178	9514	7524

Table 11 Maximum Allowable Stressing Force of Tendons with Ø15.7 mm Strand

				Y1770-15.7		Y1860-15.7	
Anchorage	n	A_p mm ²	M_p kg/m	F_{pk} kN	F_0 kN	F_{pk} kN	F_0 kN
XM/XMC-10	3	450	3.52	797	632	837	664
XM/XMC-20	4	600	4.69	1062	842	1116	886
XM/XMC-30	7	1050	8.20	1859	1474	1953	1550
XM/XMC-35	9	1350	10.55	2390	1895	2511	1993
XM/XMC-40	12	1800	14.06	3186	2527	3348	2657
XM/XMC-45	13	1950	15.24	3452	2738	3627	2878
XM/XMC-50	15	2250	17.58	3983	3159	4185	3321
XM/XMC-55	17	2550	19.92	4514	3580	4743	3764
XM/XMC-60	19	2850	22.27	5045	4001	5301	4207
XM/XMC-70	22	3300	25.78	5841	4633	6138	4871
XM/XMC-75	25	3750	29.30	6638	5265	6975	5535
XM/XMC-80	27	4050	31.64	7169	5686	7533	5978
XM/XMC-90	31	4650	36.33	8231	6529	8649	6863
XM/XMC-95	35	5250	41.02	9293	7371	9765	7749
XM/XMC-100	37	5550	43.36	9824	7792	10323	8192

1.2.4. CCL Stressing Jacks

The CCL 'MG' Stressing Jacks used for the CCL 'XM' and 'XMC' Systems have the following features:

- Automatic gripping of the wedges on the strands.
- The simultaneous stressing of all the strands of the tendon.
- Support of the Jack on the FTU, by means of a temporary Bearing Ring.
- The simultaneous hydraulic lock-off of all the wedges in the AH.
- Partial stressing of the tendons with later recovery up to the final values of the prestressing force.
- The stressing by successive loadings of the Jack when the final extension is greater than the full extension of the CCL Jack.

Other different Jacks may be used by the CCL Specialist PT Distribution/Licence Company, provided their suitability to the CCL 'XM' and 'XMC' Anchorages is approved by CCL before use.

Manuals and procedures are supplied with each CCL Stressing Jack.

Various dimensions and characteristics of CCL 'MG' Stressing Jacks are given in Annex 36 & 37. CCL 'MG' Jacks are marked on the Outer Cylinder with their Serial Numbers for identification purposes.

Different Jack innards are required for each system type.

Table 12 Jacks for Multistrand Anchorages

Anchorage	No. of Strands (15.7 mm)	No. of Strands (13.0 mm)	1800MG	3000MG	4000MG	6000MG	7500MG
XM/XMC-10	3	4	✓				
XM/XMC-20	4	6	✓				
XM/XMC-30	7	9	✓	✓			
XM/XMC-35	9	12		✓			
XM/XMC-40	12	18		✓	✓		
XM/XMC-45	13	19		✓	✓		
XM/XMC-50	15	22			✓	✓	
XM/XMC-55	17	25			✓	✓	
XM/XMC-60	19	27			✓	✓	✓
XM/XMC-70	22	31				✓	✓
XM/XMC-75	25	37				✓	✓
XM/XMC-80	27	40				✓	✓
XM/XMC-90	31	46					✓
XM/XMC-95	35	51					✓
XM/XMC-100	37	55					✓

1.2.5. Friction Losses

With Post-Tensioned steel the effect of friction may be the single greatest factor causing loss of prestress. There are three main causes of friction loss in the Post-Tensioned tendon:

- Friction due to the deviation of the tendon through the anchorage.
- Friction between the tendon and the duct due to unintentional lack of alignment (or wobble) of the duct.
- Friction due to the curvature of the duct.

Friction Loss in CCL 'XM' and 'XMC' anchorages determined from testing is 2-3 %.

Friction Loss in the duct for Post-Tensioned tendons can be estimated from:

$$\Delta P_{\mu}(x) = P_{\max} \left(1 - e^{-\mu(\theta + kx)} \right)$$

Where:

$\Delta P_{\mu}(x)$ = losses due to friction

$P_{\max}$ = force at the active end during tensioning

θ = sum of the angular displacements over a distance x (irrespective of direction or sign)

μ = coefficient of friction between the tendon and its duct

k = unintentional angular displacement (radian per unit length)

x = distance along the tendon from the point where the prestressing force is equal to $P_{\max}$

The values for the coefficient of friction, μ , and unintentional angular displacement, k , should be in line with EN 1992 Eurocode 2: Design of Concrete Structures and previous experience from site measurements, as shown in Table 13. Values for the coefficient of friction may differ in local codes and can change due to the condition of strand and duct. The user should check local codes for compliance.

Table 13 Coefficients of Friction and Unintentional Angular Displacement

Application	Duct Type	μ		k	
		Non Lubricated	Lubricated	Minimum	Maximum
Internal Prestressing	Corrugated Metal	0.19	0.17	0.005	0.01
	HDPE	0.12	0.10	0.005	0.01
	Smooth Steel Pipe	0.24	0.16	0.005	0.01
External Prestressing	HDPE	0.12	0.10	N/A	N/A
	Smooth Steel Pipe	0.24	0.16	N/A	N/A

When the tendon to be controlled has 2 Active/LE anchorages, i.e. with the tendon being able to be stressed with the Jack at both ends, the measurement on site of the friction loss of the tendon is possible by comparing the load applied by one Jack to the load measured on the other Jack.

1.2.6. Anchorage Wedge Set

CCL 'XM' and 'XMC' Jacks are equipped with a hydraulic lock-off system ensuring even seating of the wedges in the AH and Coupler before removal of the Jack. After the transfer of load from the Jack to the anchorage, the strand and wedges draw a little further into the AH or Coupler. This further movement is known as wedge set. The wedge set leads to a loss of tension in the strand, which must be taken into account in the load loss/elongation calculations.

The values for wedge set to be used in the calculations for all tendons are:

For active anchorages with Jacks with hydraulic lock-off:

- Wedge Set, $g = 6 \text{ mm} \pm 2 \text{ mm}$

For passive anchorages with spring-loaded retaining plates:

- Wedge Set, $g = 8 \text{ mm} \pm 2 \text{ mm}$

1.2.7. Tendon Elongation

The force in the tendon during stressing is measured with a hydraulic pressure gauge. Elastic elongation of the tendon can also be used to monitor this force. The designer specifies an expected elongation (including acceptable tolerance). The following formula can be used to estimate the elongation:

$$\delta = \frac{PL_t}{(A_p E_s)}$$

Where:

δ = elongation of the tendon

P = average force in a tendon

L_t = tendon length between anchorages

A_p = nominal cross-sectional area of a tendon

E_s = modulus of elasticity of the tendon steel

Before being stressed, a tendon almost always has slack in it, so a tendon is usually partially stressed up to a value of about 10 % of the specified jacking force (CCL recommend a datum of 1/3 of the specified stressing load, F_0). This point is then taken as the reference zero point for the measurement of elongation. The measurement is taken from the extension of the jack; therefore L_t must include the length of the tendon within the jack between the anchor head and the jack wedges. It is also necessary that the elongation measured from the reference point is multiplied by a correction factor before being compared to the estimated elongation specified by the designer.

1.2.8. Spacing of the Supports

For tendons in corrugated steel or plastic ducts, the maximum spacing of the supports will be 1.0 m for straight sections or sections with large radii of curvature, or 0.5 m for sections with small radii of curvature. For tendons in smooth steel tubes, spacing could be increased according to the rigidity of the tube and its slope, but cannot exceed 3.0 m.

The supports carrying the ducting should be sufficiently strong to carry the weight of the duct and the strands passing through it when threaded prior to concreting, as well as the forces occurring during and after concreting, including compaction of the concrete.

1.2.9. Radius of Curvature

Generally radius of curvature depend on duct type; minimum radius of curvature must comply with national regulations.

1.2.10. Compressive Strength of Concrete

The mean compressive strength of concrete at which full prestressing is permitted, $f_{cm,0}$, specified by the designer of the structure must be greater than or equal to 30 MPa cube strength. In the case of partial stressing of a standard anchorage to 50 % of F_{pk} , the minimum mean compressive strength of concrete could be reduced by 30 %.

1.2.11. Anchorage Spacing and Concrete Cover

Taking into account the tested values of mean compressive concrete strength, $f_{cm,0}$, (30 MPa and 55 MPa cube strength for units XM10-100); the test specimen side lengths of the end block (a and b) are provided in Annex 27 for 3 levels of mean compressive concrete strength.

For values of $f_{cm,0}$ between 30 MPa and 55 MPa cube strength, a and b can be determined by straight line interpolation, as is the case for values quoted for $f_{cm,0}$ on cube = 45 MPa.

For the tested value of mean compressive strength, $f_{cm,0}$, (46 MPa cube strength for units XM10-80); the test specimen side lengths of the end block (a and b) are provided in Annex 33.

The minimum concrete cover from the reinforcement to the edge of the structure, c_{min} , should be established according to EN 1992 Eurocode 2: Design of Concrete Structures and must be take into account when determining the minimum distances from the axis of an anchorage to the edge of the structure (e_x and e_y).

Given the test specimen side lengths a and b in Annex 27 & 33, the minimum distances between two axes of anchorages (x and y) and to the edge of the structure (e_x and e_y) result from the following formulae (where c is the concrete cover):

- $A_c = x . y \geq a . b$
- $x \geq 0.85 a$
- $y \geq 0.85 b$
- $e_x = \frac{x}{2} - 10 \text{ mm} + c$
- $e_y = \frac{y}{2} - 10 \text{ mm} + c$

1.3. Installation

The CCL 'XM' and 'XMC' anchorages are fit for use in suitably designed structures. The designer of the structure is assumed to respect the relevant specifications set by applicable standards and to adapt their design in accordance with these standards and the advice of the ETA holder.

1.3.1. Anchorages

The FTU is fixed to the formwork, then the DC is screwed into the FTU, in the case of the encapsulated system, the joint between the FTU and DC is sealed using a heat shrink sleeve. The local bursting reinforcement is attached with the general reinforcement.

The ducting is connected, and the sealing of the connection between the duct and the anchorage is carried out, either by an adhesive sealing tape, or a heat-shrink sleeve, in the case of the encapsulated system, a plastic sleeve and a heat-shrink sleeve are used at each duct connection.

To facilitate the installation of the AH or Coupler and the wedges a sufficient open space must be reserved behind each anchorage. This open space must also allow for implementation of sealing caps.

Setting out dimensions of the anchorage and space reserved behind each anchorage are to be checked before concreting.

AH or Coupler (1st Stage) and wedges are assembled immediately prior to stressing of the tendon in order to avoid corrosion.

1.3.1.1 Active Anchorages:

Sufficient space must be reserved behind the anchorage for the installation and operation of the stressing Jack.

Stressing must only be carried out when the concrete has cured to the required minimum compressive strength.

The cut length of the strands, calculated from exposed face of the FTU must be sufficient to allow installation of the AH or Coupler and wedges, the threading of the stressing Jack and insertion of the Jack wedges. These lengths should be checked with the local agent to ensure the suitability to the particular stressing Jack to be used.

1.3.1.2 Passive Anchorages

For tendons where the tension is applied at one end only, a live end anchorage or a dead end anchorage can be used. When a dead end is used, the wedge retaining plates and springs are fixed to the AH or Coupler holding the wedges in place with sufficient force to help prevent wedge-stepping.

The cut length of the strands, calculated from exposed face of the FTU must be sufficient to allow installation of the AH or Coupler and wedges, then the locking of the wedges with the retaining plate and springs. An extra length of 50 mm beyond the AH or Coupler is necessary.

1.3.1.3 Deviators for External Tendons

For this ETA, no deviators has been tested according to the deviated tendon test of EAD 160004-00-0301. Unless there are stricter regulations at the place of use, external tendon deviators must be in line with French Fascicule 65 of C.C.T.G. – chapter 11.

1.3.2. Pre-Sealing and Grouting of Anchorages

After stressing and cutting back of the tendon, CCL 'XM' and 'XMC' anchorages can be equipped with temporary or permanent sealing caps fixed onto the FTU or coupler, respectively. This makes it possible to inject the ducts before the final sealing.

1.3.3. Corrosion Protection

After stressing of the tendon, the free volume between the duct and the strands is filled to protect the tendon from corrosion.

CCL 'XM' and 'XMC' anchorages shall be injected with a corrosion protection substance in accordance with the local regulations and with the specifications of implementation laid out by CCL.

Corrosion protection is usually carried out in internal prestressing in concrete by a cement grout which ensures a mechanical connection between the reinforcement and the concrete structure. Common grouts must comply with requirements of EN 445, EN 446 and EAD 160027-00-0301. Common grout to be used should have been subject to and have results of the inclined tube test as laid out in EAD 160027-00-0301.

Grouting procedures should conform to EN 447 and *fib* Bulletin No. 20 "Grouting of tendons in prestressed concrete". Manufacture and the placement of a cement grout must respect the local specifications and the guidelines laid out in EAD 160027-00-0301.

Greases and Waxes of various origins can be used with the CCL 'XM' System, especially for external PT. Greases and Waxes must conform to the specifications of EAD 160027-00-0301.²

An up to date list of corrosion protection products that can be used with the CCL 'XM' and 'XMC' System is available from CCL.

² Grease and Waxes have not been tested for the delivery of this ETA. They shall comply with EAD 160027-00-0301.

2. Specifications of the intended use in accordance with the applicable European Assessment Document

2.1. Intended use

2.1.1. For 'XM' Multistrand Bonded/Unbonded System

Basic categories of use are:

- Internal bonded tendon for concrete and composite structures
- Internal unbonded tendon for concrete and composite structures
- External tendon for concrete structures with a tendon path situated outside the cross-section of the structure or member but inside its envelope

Optional categories of use are:

- Bonded tendon for cryogenic applications inside the possible cryogenic zone
- Internal bonded tendon with plastic duct
- Encapsulated tendon

The design of the load introduction zone supporting the PT anchorage system must comply with relevant Eurocodes and regulations in force at the place of use.

2.1.2. For 'XMC' Multistrand Coupler Bonded Post-Tensioning System

Basic categories of use are:

- Internal bonded tendon for concrete and composite structures
- Internal unbonded tendon for concrete and composite structures
- External tendon for concrete structures with a tendon path situated outside the cross-section of the structure or member but inside its envelope

Optional categories of use are :

- Internal bonded tendon with plastic duct

The design of the load introduction zone supporting the PT anchorage system must comply with relevant Eurocodes and regulations in force at the place of use.

2.2. Working life

The provisions made in this ETA are based on an assumed intended working life of the CCL 'XM' and 'XMC' PT System of 100 years (provided that the conditions laid down for packaging / transport / storage / installation / use / maintenance / repair are met). The indications given on the working life cannot be interpreted as a guarantee given by the producer or the approval body, but are to be regarded only as a means for choosing the right products in relation to the expected economically reasonable working life of the works.

3. Performance of the products and methods used for its assessment

This European Technical Assessment for the post-tensioning system part of this document is issued on the basis of agreed data, deposited at Cerema, which identifies the post-tensioning system that has been assessed and judged.

Assessment of the performance of the post-tensioning system part of this document for the intended use in the sense of Basic Works Requirement 1 (mechanical resistance and stability) has been made in accordance with the EAD 160004-00-0301.

Product type: Post-Tensioning kit		Intended use: Prestressing of structures
N°	Essential characteristic (acc. to EAD 160004-00-0301)	Product Performance
Basic requirement for construction works 1: Mechanical resistance and stability		
1	Resistance to static load	≥ 95 % of Actual Ultimate Tensile Strength – AUTS (acceptance criteria given in clause 2.2.1 of EAD 160004-00-0301)
2	Resistance to fatigue	No fatigue failure in anchorage and not more than 5 % loss on cross section after 2 millions cycles (acceptance criteria given in clause 2.2.2 of EAD 160004-00-0301)
3	Load transfer to the structure	Stabilization of crack width under cyclic load and ultimate resistance ≥ 110 % characteristic load (acceptance criteria given in clause 2.2.3 of EAD 160004-00-0301)
4	Friction coefficient	See Clause 1.2.5 (acceptance criteria given in clause 2.2.4 of EAD 160004-00-0301)
5	Deviation / deflection for internal unbonded tendon	See Clause 1.2.9 (acceptance criteria given in clause 2.2.5 of EAD 160004-00-0301)
6	Deviation / deflection for external unbonded tendon	See Clause 1.2.9 (acceptance criteria given in clause 2.2.6 of EAD 160004-00-0301)
7	Assessment of assembly	Installation of strands, duct filling
13	Corrosion protection	See Clause 1.3.3 (acceptance criteria given in clause 2.2.13 of EAD 160004-00-0301)

4. Assessment and verification of constancy of performance system applied, with reference to its legal base

In accordance with the decision 98/456/EC³ of the European Commission, the system 1+ of assessment and verification of constancy of performances (see Annex V to Regulation (EU) No 305/2011), given in the following table applies:

Product(s)	Intended use(s)	Level(s) or class(es)	System(s)
Post-tensioning Kits	For the prestressing of structures	-	1+

This AVCP system is defined as follows:

System 1+: Declaration of the performance of the essential characteristics of the construction product by the manufacturer on the basis of the following items:

- (a) Tasks of the manufacturer
 - (1) Factory production control;
 - (2) Further testing of samples taken at the factory by the manufacturer in accordance with a prescribed test plan;
- (b) Tasks for the notified body
 - (3) Determination of the product-type on the basis of type testing (including sampling), type calculation, tabulated values or descriptive documentation of the product;
 - (4) Initial inspection of factory and of factory production control;
 - (5) Continuous surveillance, assessment and approval of factory production control;
 - (6) Audit testing of samples taken at the factory.

³ Official Journal of the European communities L201/112 of 3 July 1998

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 manufacturer shall exercise permanent internal control of production. All the elements, requirements and provisions adopted by the manufacturer shall be documented in a systematic manner in the form of written policies and procedures including records or results performed. This production control system shall insure that the product is in conformity with this European Technical Assessment.

The manufacturer shall only use initial / raw / constituent materials (as relevant) stated in the technical documentation of this European Technical Assessment.

The factory production control shall be in accordance with the "CCL Control Plan" relating to this European Technical Assessment which is part of the technical documentation of this European Technical Assessment. The "Control Plan" is laid down in the context of the factory production control system operated by the manufacturer and deposited at Cerema.

The prescribed test plan defined in Annex 38 and 39 gives the type and frequency of checks and tests conducted during production and on the final product as part of the continuous internal production control.

The results of factory production control shall be recorded and evaluated in accordance with the provisions of the "CCL Control Plan" relating to this European Technical Assessment.

The records contain at least the following information:

- designation of the product or basic materials and the components;
- type of control or testing;
- date of manufacture and of testing of product or components and of basic materials or components;
- results of controls and tests and, where relevant, comparison with the requirements;
- signature of person responsible for the factory production control.

The kit manufacturer is responsible for the manufacture and the quality of each component that is manufactured or supplied by a subcontractor.

If the test results are unsatisfactory, the manufacturer shall immediately implement measures to eliminate defects. Construction products or components which are not in compliance with the requirements shall be handled such that they cannot be mistaken for products complying with the requirements. After elimination of the defects the relevant tests shall be immediately repeated as far as is technically possible and necessary for verifying the deficiency elimination.

The records shall be kept for at least ten years and submitted to the notified body. On request they shall be presented to Cerema.

5.1.2. Other tasks

The manufacturer shall, on the basis of a contract, involve a body (bodies) which is (are) notified for the tasks referred to in section 5.2 in the field of CCL post-tensioning system in order to undertake the actions laid down in section 5.2. For this purpose, the "CCL Control Plan" referred to in sections 5.1 and 5.2 shall be handed over by the manufacturer to the notified body or bodies involved.

The manufacturer shall make a declaration of performance, stating that the construction product is in conformity with the provisions of this European Technical Assessment.

At least once a year, each components manufacturer shall be audited by the kit manufacturer.

At least once a year specimens shall be taken from at least one job site and one series of single tensile element test shall be performed according to EAD 160004-00-0301, Annex C.7 (see Annex 40). The results of these test series shall be made available to the notified body.

5.2. Tasks of the Notified body

5.2.1. General

The notified body (bodies) shall perform the :

- Determination of the product-type on the basis of type testing (including sampling), type calculation, tabulated values or descriptive documentation of the product,
- Initial inspection of factory and of factory production control,
- Continuous surveillance, assessment and approval of factory production control,
- Audit-testing of samples taken at the factory

in accordance with the provisions laid down in the "CCL Control Plan" relating to this European Technical Assessment.

The notified body (bodies) shall retain the essential points of its actions referred to above and state the results obtained and conclusions drawn in a written report.

The main production centre is checked at least once a year by the notified body. Each component producer is checked at least once every five years by the notified body.

The notified certification body involved by the manufacturer shall issue a certificate of constancy of performance of the product stating the conformity with the provisions of this European Technical Assessment.

In cases where the provisions of the European Technical Assessment and its "Control Plan" are no longer fulfilled the certification body shall withdraw the certificate of constancy of performances and inform Cerema without delay.

5.2.2. Determination of the product-type on the basis of type testing (including sampling), type calculation, tabulated values or descriptive documentation of the product

For initial type testing the results of the tests performed as part of the assessment of the European Technical Assessment may be used unless there are changes in production procedure or factory plant. In such cases, the necessary initial type testing shall be agreed between Cerema and the notified body involved.

5.2.3. Initial inspection of factory and of factory production control

The notified body shall ascertain 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 orderly manufacturing of the post-tensioning system according to the specifications given in this European Technical Assessment.

5.2.4. Surveillance, assessment and approval of factory production control

The kit manufacturer shall be inspected at least once a year. Each component manufacturer shall be inspected at least once in five years. It shall be verified that the system of factory production control and the specified manufacturing process are maintained taking into account the prescribed test plan.

5.2.5. Audit testing of samples taken from the kit manufacturer

During surveillance inspection, the notified body shall take samples at the factory of components of the PT system or of individual components for which this European Technical Assessment has been granted, for independent testing. For the most important components Annex 38, complying with EAD 160004-00-0301 Table 4, summarises the minimum procedures which have to be performed by the certification body.

Issued in Sourdun on 01.12.2021

By
Centre d'étude et d'expertise sur les risques, l'environnement, la mobilité et l'aménagement
(Cerema)
Direction technique Infrastructures de transport et matériaux (DTecITM)

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Date : 2021.12.02
10:41:25 +01'00'

Éric MOULINE (deputy director of Cerema ITM), ETA manager

Designation of tendon

Prestressing steel:

- | | | |
|--|----------|--|
| - Type: | | Strand according to prEN 10183-3: 2006 |
| - Strength: | f_{pk} | 1860 MPa or 1770 MPa |
| - Nominal cross section: | A_s | See 1.2.3.3 Strand Characteristics |
| - Relaxation at $0.70f_{pk}$ after 1000 hours: | | 2.5 % |
| - Modulus of elasticity: | E_s | 195 GPa |

Tendon:

- | | | |
|---|-------------------|---|
| - Type: | | Internal/External Bonded/Unbonded |
| - Use category: | | Concrete, Composite, Steel, Masonry, Timber |
| - Corrosion protection: | | Grout, Grease, Wax |
| - Weight of tendon: | M_p | See 1.2.3.4 Prestressing Forces |
| - Force at $1.00f_{pk}$: | F_{pk} | See 1.2.3.4 Prestressing Forces |
| - Friction coefficient: | μ | See 1.2.5 Friction Losses |
| - Unintentional deviation/
Wobble coefficient: | k | See 1.2.5 Friction Losses |
| - Minimum radius of curvature: | R_{min} | See 1.2.9 Radii of Curvature |
| - Duct outside & inside diameter: | $d_{out} d_{int}$ | See Annex 22 and 23 |
| - Maximum spacing
of duct supports: | s_{max} | See 1.2.8 Spacing of the Supports |

Anchorage:

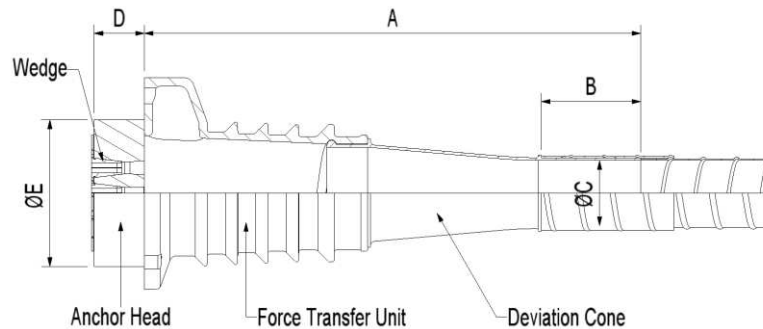
- | | | |
|---------------------------|------------|--|
| - Type: | | See 1.2.1 – 1.2.2 & Annexes 2 to 35 |
| - Minimum centre spacing: | x, y | See Annex 27, 33 and
1.2.11 Anchorage Spacing and
Concrete Cover |
| - Minimum edge distance: | e_x, e_y | See Annex 27, 33 and
1.2.11 Anchorage Spacing and
Concrete Cover |
| - Anchorage seating: | g | See 1.2.6 Anchorage Wedge Set |



CCL 'XM' / 'XMC' Systems

Annex 01
of ETA-07/0035

Live End Anchorage Ø15.2/15.3/15.7 mm Strand



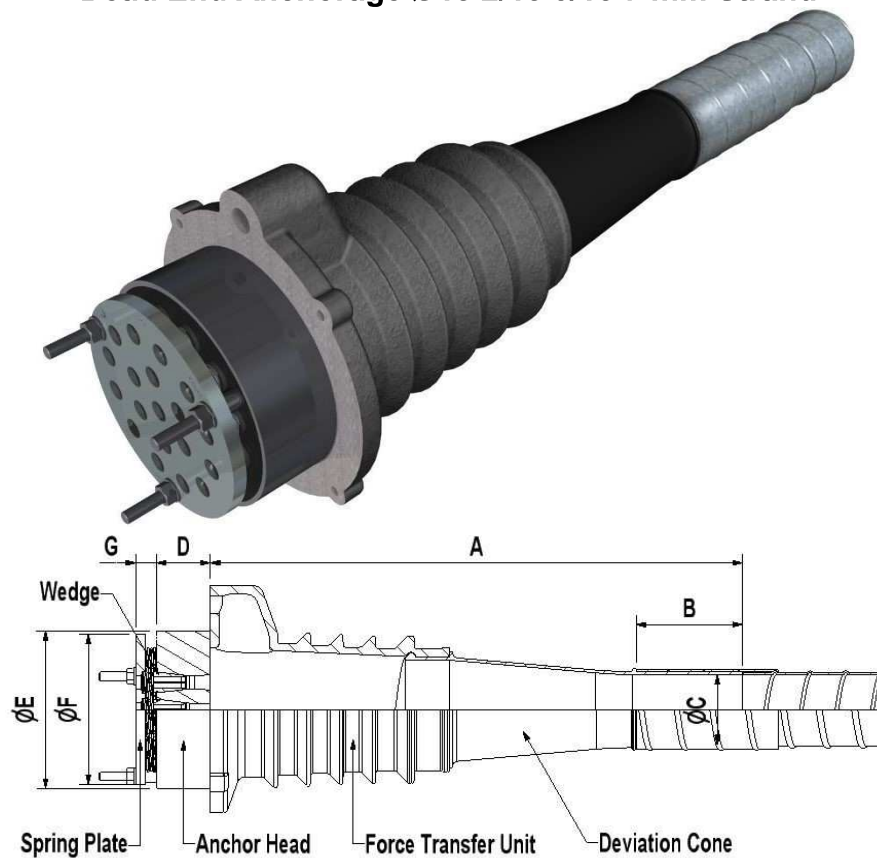
Anchorage	A	B	ØC	D	ØE
XM-10	234	70	48	45	95
XM-20	300	70	50	45	105
XM-30	362	100	64	48	130
XM-35	493	113	74	47	155
XM-40	629	113	74	54	180
XM-45	629	113	74	63	180
XM-50	693	130	84	60	195
XM-55	742	150	98	62	215
XM-60	749	150	98	76	220
XM-70	913	150	98	70	245
XM-75	1001	175	113	80	265
XM-80	1001	175	113	83	270
XM-90	1118	190	123	94	295
XM-95	1079	210	138	94	305
XM-100	1089	210	138	102	310



CCL 'XM' System
Live End Anchorage
Ø15.2/15.3/15.7 mm Strand

Annex 02
of ETA-07/0035

Dead End Anchorage Ø15.2/15.3/15.7 mm Strand



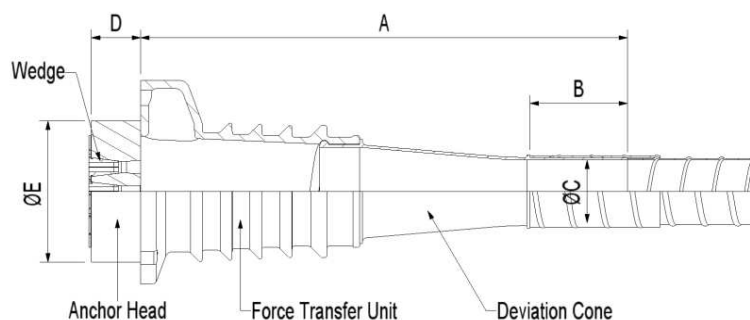
Anchorage	A	B	ØC	D	ØE	ØF	G
XM-10	234	70	48	45	95	95	29
XM-20	300	70	50	45	105	105	29
XM-30	362	100	64	48	130	130	29
XM-35	493	113	74	47	155	155	29
XM-40	629	113	74	54	180	180	29
XM-45	629	113	74	63	180	180	29
XM-50	693	130	84	60	195	195	29
XM-55	742	150	98	62	215	215	29
XM-60	749	150	98	76	220	220	29
XM-70	913	150	98	70	245	245	29
XM-75	1001	175	113	80	265	265	29
XM-80	1001	175	113	83	270	270	29
XM-90	1118	190	123	94	295	295	29
XM-95	1079	210	138	94	305	305	29
XM-100	1089	210	138	102	310	310	29



CCL 'XM' System
Dead End Anchorage
Ø15.2/15.3/15.7 mm Strand

Annex 03
of ETA-07/0035

Live End Anchorage Ø12.5/12.9/13.0 mm Strand



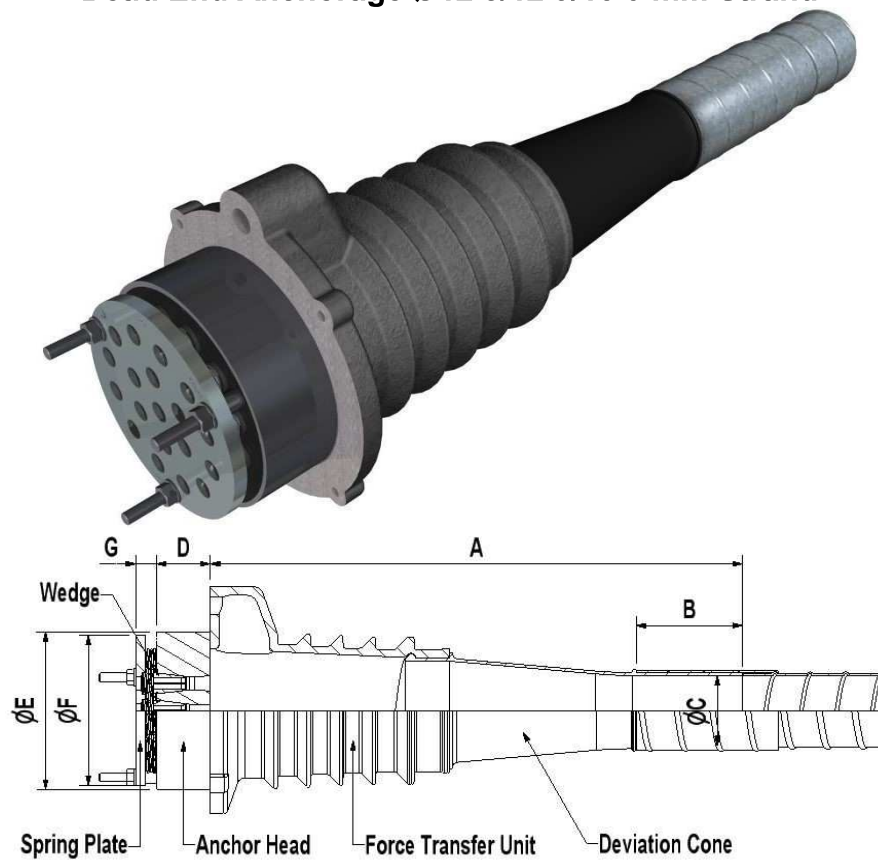
Anchorage	A	B	ØC	D	ØE
XM-10	234	70	48	40	95
XM-20	300	70	50	40	105
XM-30	362	100	64	43	130
XM-35	493	113	74	48	155
XM-40	629	113	74	62	180
XM-45	629	113	74	67	180
XM-50	693	130	84	69	195
XM-55	742	150	98	67	215
XM-60	749	150	98	76	220
XM-70	913	150	98	74	245
XM-75	1001	175	113	80	265
XM-80	1001	175	113	84	270
XM-90	1118	190	123	87	295
XM-95	1079	210	138	97	305
XM-100	1089	210	138	98	310



CCL 'XM' System
Live End Anchorage
Ø12.5/12.9/13.0 mm Strand

Annex 04
of ETA-07/0035

Dead End Anchorage Ø12.5/12.9/13.0 mm Strand



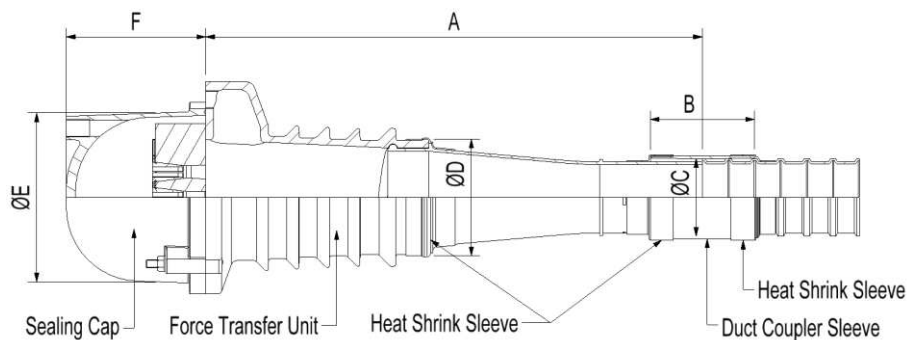
Anchorage	A	B	ØC	D	ØE	ØF	G
XM-10	234	70	48	40	95	95	29
XM-20	300	70	50	40	105	105	29
XM-30	362	100	64	43	130	130	29
XM-35	493	113	74	48	155	155	29
XM-40	629	113	74	62	180	180	29
XM-45	629	113	74	67	180	180	29
XM-50	693	130	84	69	195	195	29
XM-55	742	150	98	67	215	215	29
XM-60	749	150	98	76	220	220	29
XM-70	913	150	98	74	245	245	29
XM-75	1001	175	113	80	265	265	29
XM-80	1001	175	113	84	270	270	29
XM-90	1118	190	123	87	295	295	29
XM-95	1079	210	138	97	305	305	29
XM-100	1089	210	138	98	310	310	29



CCL 'XM' System
Dead End Anchorage
Ø12.5/12.9/13.0 mm Strand

Annex 05
of ETA-07/0035

Encapsulated Live End Anchorage Ø15.2/15.3/15.7 mm/12.5/12.9/13.0 mm Strand



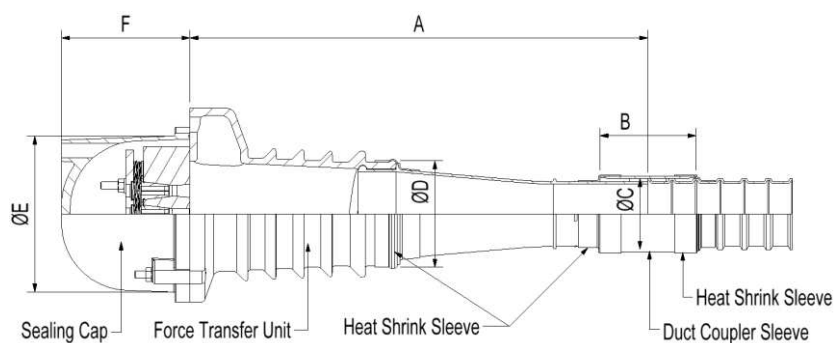
Anchorage	A	B	ØC	ØD	ØE	F
XM-10	234	70	48	80	-	-
XM-20	300	70	50	93	-	-
XM-30	362	100	64	111	-	-
XM-35	493	113	74	130	185	160
XM-40	629	113	74	146	211	190
XM-45	629	113	74	146	211	190
XM-50	693	130	84	158	231	190
XM-55	742	150	98	174	247	195
XM-60	749	150	98	174	255	210
XM-70	913	150	98	193	280	210
XM-75	1001	175	113	209	305	210
XM-80	1001	175	113	209	319	220
XM-90	1118	190	123	230	344	210
XM-95	1079	210	138	232	361	235
XM-100	1089	210	138	232	361	235



CCL 'XM' System
Encapsulated Live End Anchorage
Ø15.2/15.3/15.7 mm/12.5/12.9/13.0 mm Strand

Annex 06
of ETA-07/0035

Encapsulated Dead End Anchorage Ø15.2/15.3/15.7 mm/12.5/12.9/13.0 mm Strand



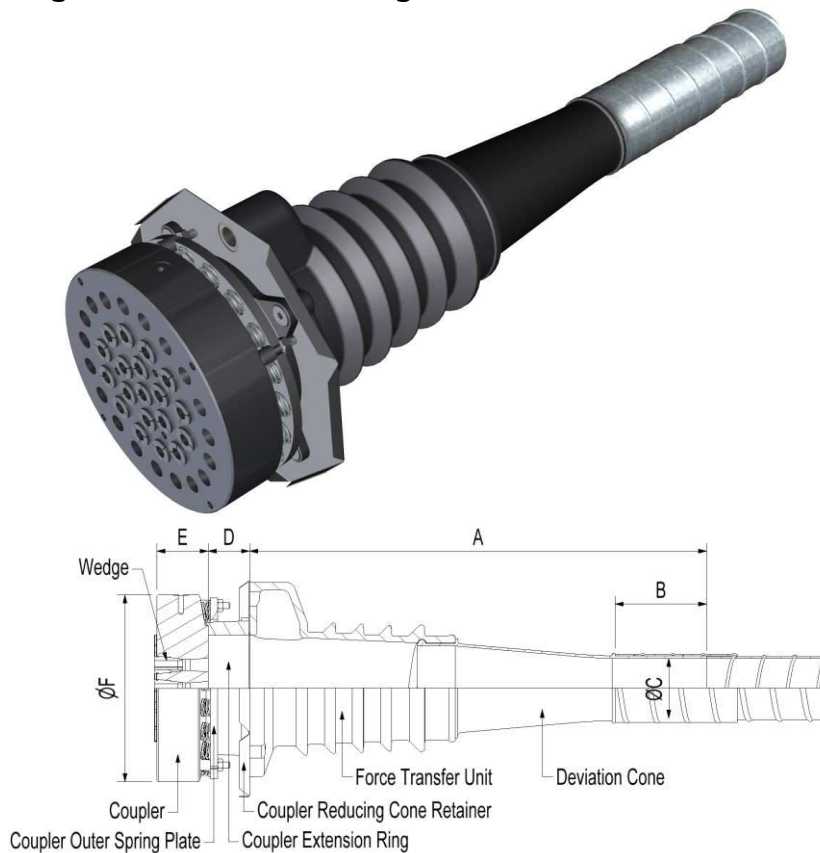
Anchorage	A	B	ØC	ØD	ØE	F
XM-10	234	70	48	80	-	-
XM-20	300	70	50	93	-	-
XM-30	362	100	64	111	-	-
XM-35	493	113	74	130	185	160
XM-40	629	113	74	146	211	190
XM-45	629	113	74	146	211	190
XM-50	693	130	84	158	231	190
XM-55	742	150	98	174	247	195
XM-60	749	150	98	174	255	210
XM-70	913	150	98	193	280	210
XM-75	1001	175	113	209	305	210
XM-80	1001	175	113	209	319	220
XM-90	1118	190	123	230	344	210
XM-95	1079	210	138	232	361	235
XM-100	1089	210	138	232	361	235



CCL 'XM' System
Encapsulated Dead End Anchorage
Ø15.2/15.3/15.7 mm/12.5/12.9/13.0 mm Strand

Annex 07
of ETA-07/0035

Stage 1 Live End Anchorage Ø15.2/15.3/15.7 mm Strand



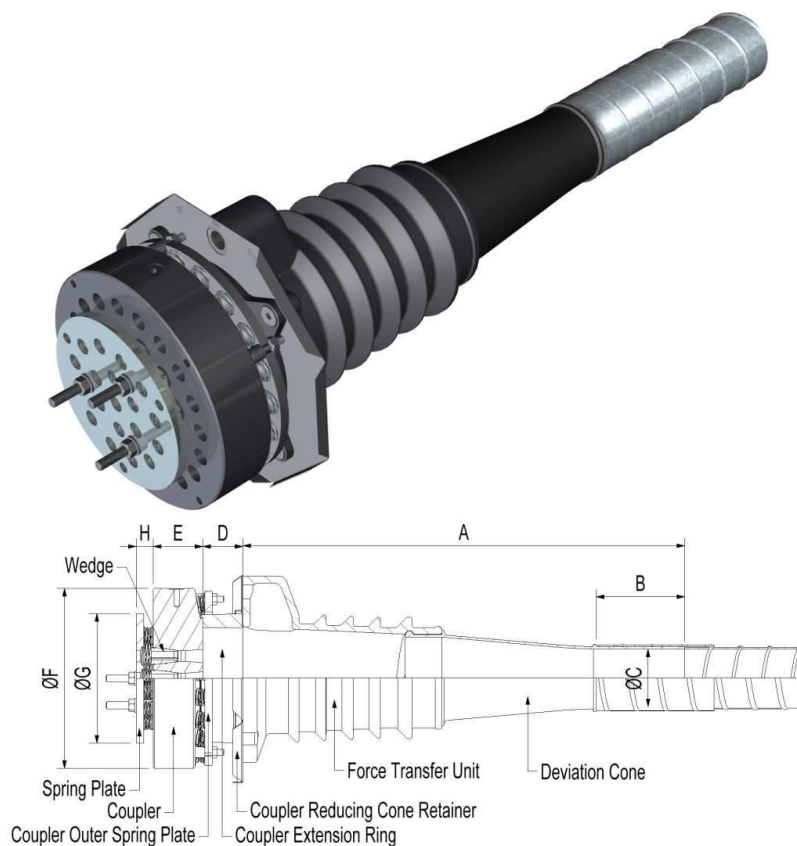
Anchorage	A	B	ØC	D	E	ØF
XMC-10	234	70	48	67	60	185
XMC-20	300	70	50	67	60	195
XMC-30	362	100	64	67	60	220
XMC-35	493	113	74	67	60	245
XMC-40	629	113	74	67	69	265
XMC-45	629	113	74	67	71	265
XMC-50	693	130	84	67	75	285
XMC-55	742	150	98	67	77	300
XMC-60	749	150	98	67	84	305
XMC-70	913	150	98	67	86	325
XMC-75	1001	175	113	67	92	350
XMC-80	1001	175	113	67	96	375
XMC-90	1118	190	123	67	109	410
XMC-95	1079	210	138	67	112	430
XMC-100	1089	210	138	67	116	435



CCL 'XMC' System
Stage 1 Live End Anchorage
Ø15.2/15.3/15.7 mm Strand

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of ETA-07/0035

Stage 1 Dead End Anchorage Ø15.2/15.3/15.7 mm Strand



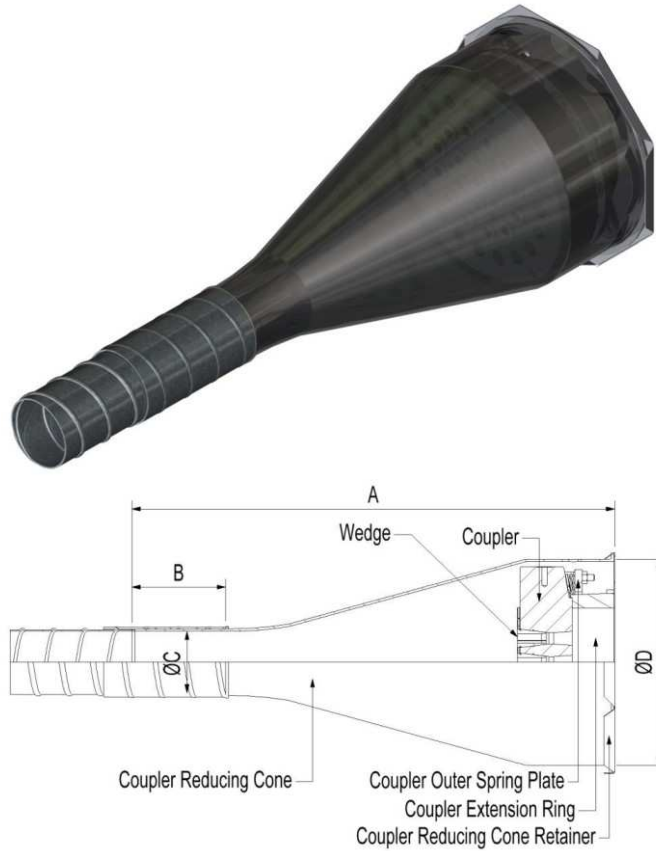
Anchorage	A	B	ØC	D	E	ØF	ØG	H
XMC-10	234	70	48	67	60	185	95	29
XMC-20	300	70	50	67	60	195	105	29
XMC-30	362	100	64	67	60	220	130	29
XMC-35	493	113	74	67	60	245	155	29
XMC-40	629	113	74	67	69	265	180	29
XMC-45	629	113	74	67	71	265	180	29
XMC-50	693	130	84	67	75	285	195	29
XMC-55	742	150	98	67	77	300	215	29
XMC-60	749	150	98	67	84	305	220	29
XMC-70	913	150	98	67	86	325	245	29
XMC-75	1001	175	113	67	92	350	265	29
XMC-80	1001	175	113	67	96	375	270	29
XMC-90	1118	190	123	67	109	410	295	29
XMC-95	1079	210	138	67	112	430	305	29
XMC-100	1089	210	138	67	116	435	310	29



CCL 'XMC' System
Stage 1 Dead End Anchorage
Ø15.2/15.3/15.7 mm Strand

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of ETA-07/0035

Stage 2 Anchorage Ø15.2/15.3/15.7 mm Strand



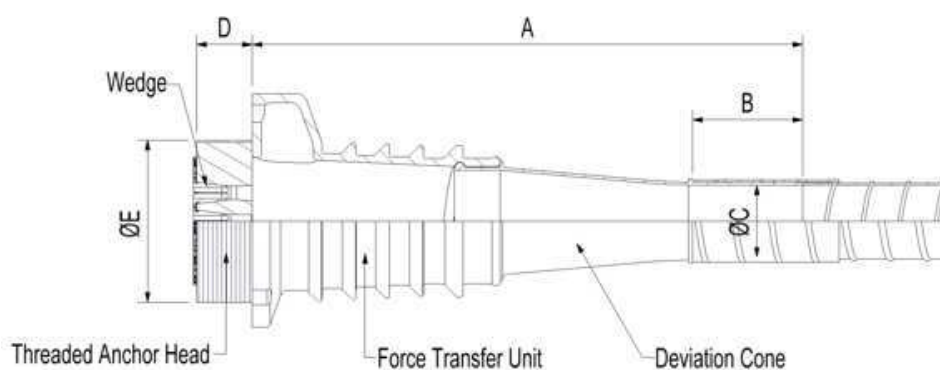
Anchorage	A	B	ØC	ØD
XMC-10	496	70	48	201
XMC-20	518	70	50	211
XMC-30	579	100	64	236
XMC-35	635	113	74	261
XMC-40	692	113	74	284
XMC-45	692	113	74	284
XMC-50	737	130	84	301
XMC-55	760	150	98	318
XMC-60	774	150	98	329
XMC-70	831	150	98	381
XMC-75	884	175	113	391
XMC-80	1174	175	113	406
XMC-90	1250	190	123	434
XMC-95	1270	210	138	452
XMC-100	1270	210	138	452



CCL 'XMC' System
Stage 2 Anchorage
Ø15.2/15.3/15.7 mm Strand

Annex 10
of ETA-07/0035

Threaded Anchor Head Live End Anchorage Ø15.2/15.3/15.7 mm Strand



Anchorage	A	B	ØC	D	ØE
XM-10	234	70	48	45	Tr115 x 6 (*)
XM-30	362	100	64	48	Tr150 x 6 (*)
XM-40	629	113	74	54	Tr210 x 6 (*)
XM-60	749	150	98	76	Tr240 x 6 (*)
XM-70	913	150	98	70	Tr270 x 6 (*)

(*) See thread table

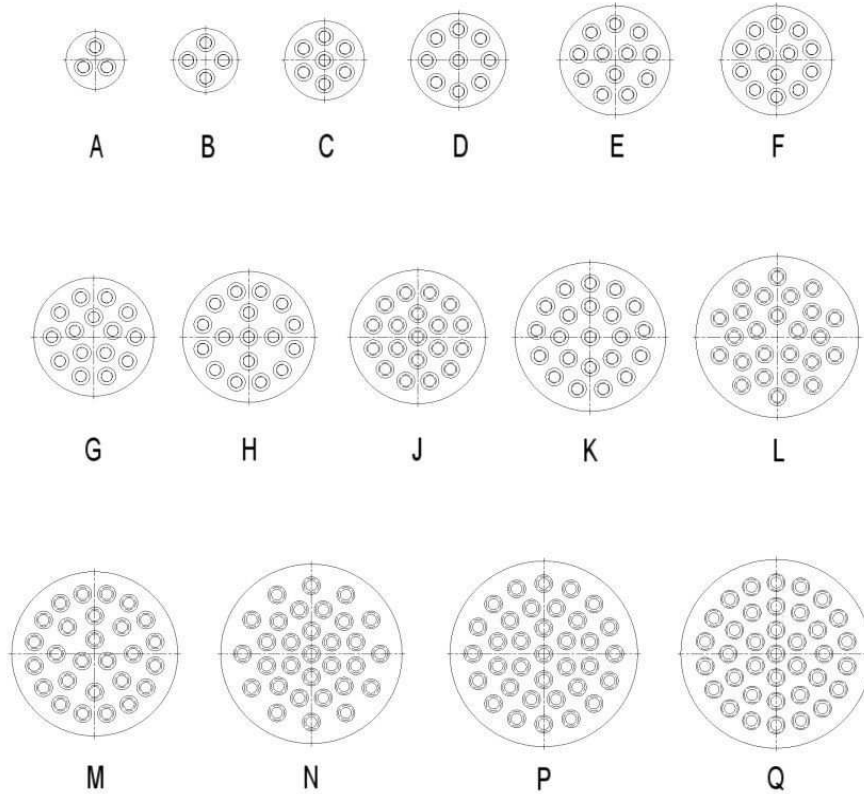
Thread table						
Thread	Major		Effective		Minor	
	Max	Min	Max	Min	Max	Min
Tr115 x 6	114.8	114.5	111.8	111.5	107.8	107.5
Tr150 x 6	149.8	149.5	146.8	146.5	142.8	142.5
Tr210 x 6	209.8	209.5	206.8	206.5	202.8	202.5
Tr240 x 6	239.8	239.5	236.8	236.5	232.8	232.5
Tr270 x 6	269.8	269.5	266.8	266.5	262.8	262.5



CCL 'XM' System
Threaded Anchor Head Live End Anchorage
Ø15.2/15.3/15.7 mm Strand

Annex 11
of ETA-07/0035

Anchor Head Hole Patterns Ø15.2/15.3/15.7 mm Strand



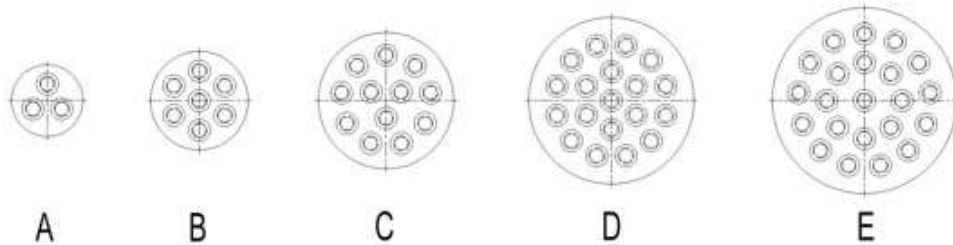
Anchorage	<i>n</i>	Layout
XM-10	3	A
XM-20	4	B
XM-30	7	C
XM-35	9	D
XM-40	12	E
XM-45	13	F
XM-50	15	G
XM-55	17	H
XM-60	19	J
XM-70	22	K
XM-75	25	L
XM-80	27	M
XM-90	31	N
XM-95	35	P
XM-100	37	Q



CCL 'XM' System
Anchor Head Hole Patterns
Ø15.2/15.3/15.7 mm Strand

Annex 13
of ETA-07/0035

Threaded Anchor Head Hole Patterns Ø15.2/15.3/15.7 mm Strand



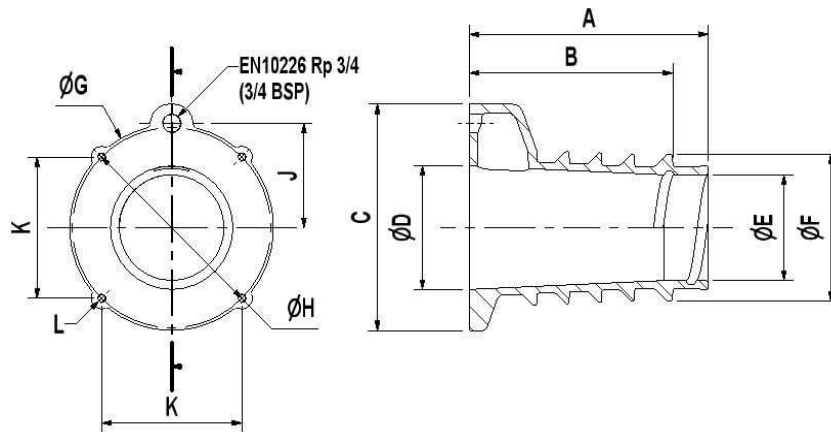
Anchorage	<i>n</i>	Layout
XM-10	3	A
XM-30	7	B
XM-40	12	C
XM-60	19	D
XM-70	22	E



CCL 'XM' System
Threaded Anchor Head Hole Patterns
Ø15.2/15.3/15.7 mm Strand

Annex 14
of ETA-07/0035

Force Transfer Unit



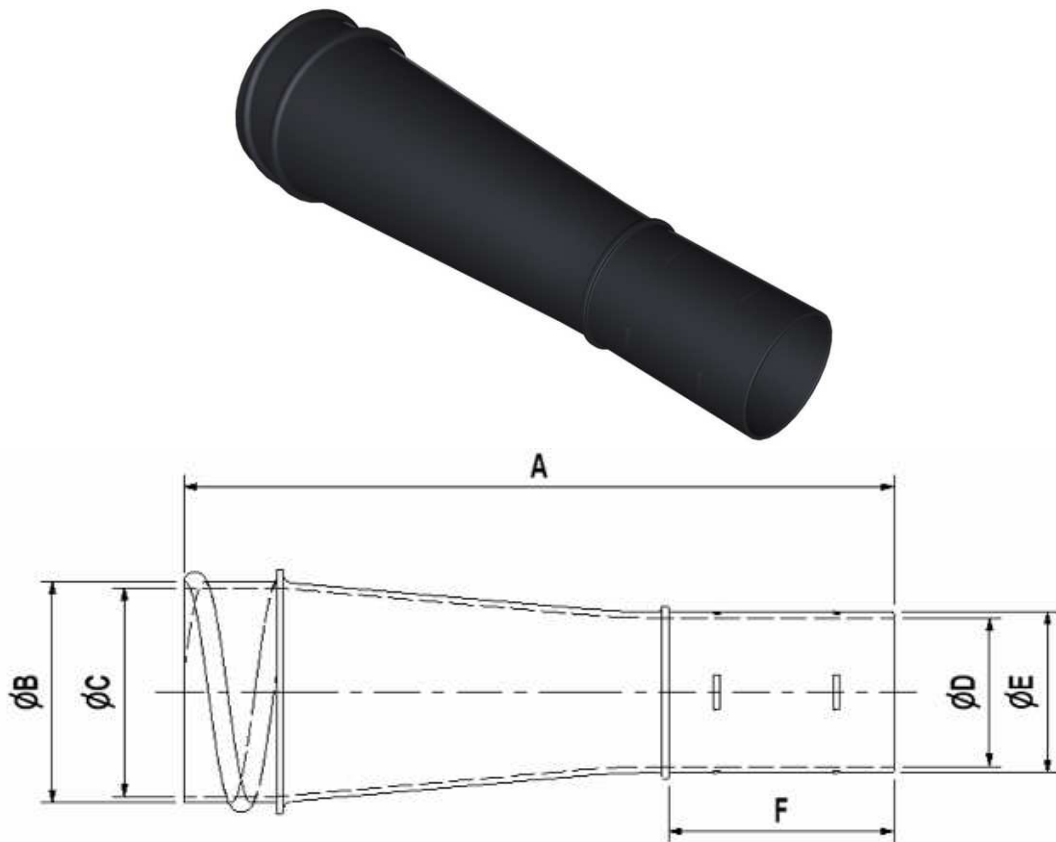
Anchorage	A	B	C	ØD	ØE	ØF	ØG	ØH	J	K	L
XM/XMC-10	160	130	149	66	60	113	130	130	65	92	M8
XM/XMC-20	170	140	160	80	68	126	140	140	70	99	M8
XM/XMC-30	228	178	195	98	86	144	178	168	83	119	M10
XM/XMC-35	270	220	231	123	105	163	200	210	110	148	M12
XM/XMC-40	275	225	266	138	121	178	232	236	123	167	M12
XM/XMC-45	275	225	270	138	121	178	236	236	125	167	M12
XM/XMC-50	310	260	291	154	132	191	260	253	134	179	M12
XM/XMC-55	330	280	309	173	148	207	280	270	142	191	M12
XM/XMC-60	337	287	317	173	148	206	288	280	146	198	M12
XM/XMC-70	370	320	351	193	165	225	320	325	164	230	M16
XM/XMC-75	418	368	376	216	181	241	345	335	176	237	M16
XM/XMC-80	418	368	390	216	181	241	360	350	183	247	M16
XM/XMC-90	440	390	418	238	200	263	390	378	196	267	M16
XM/XMC-95	480	430	433	247	202	266	405	396	203	280	M16
XM/XMC-100	490	440	435	250	202	264	410	396	203	280	M16



CCL 'XM' / 'XMC' Systems
Force Transfer Unit

Annex 17
of ETA-07/0035

Deviation Cone



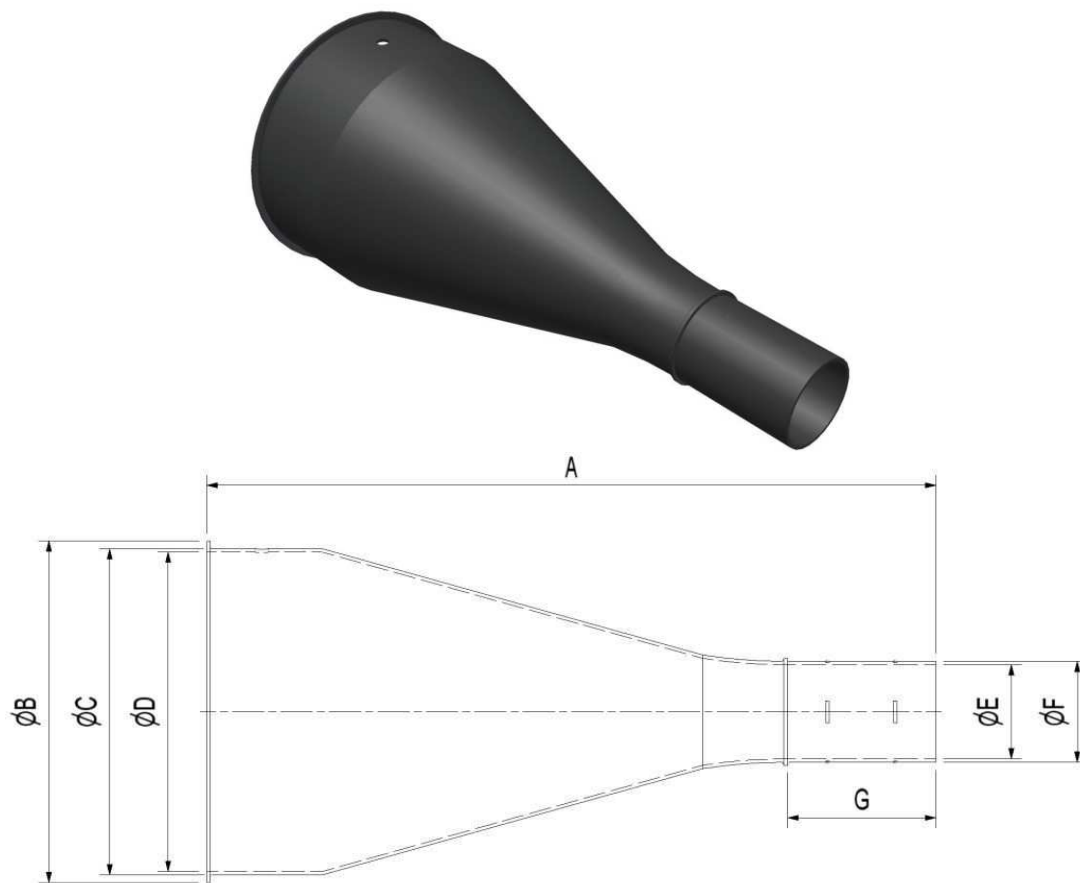
Anchorage	A	ØB	ØC	ØD	ØE	F
XM/XMC-10	114	58	53	48	56	70
XM/XMC-20	170	66	62	50	58	70
XM/XMC-30	196	84	79	64	72	100
XM/XMC-35	285	103	95	74	82	113
XM/XMC-40	416	119	111	74	82	113
XM/XMC-45	416	119	111	74	82	113
XM/XMC-50	445	130	122	84	92	130
XM/XMC-55	474	146	138	98	106	150
XM/XMC-60	474	146	138	98	106	150
XM/XMC-70	605	163	155	98	106	150
XM/XMC-75	645	179	171	113	121	175
XM/XMC-80	645	179	171	113	121	175
XM/XMC-90	740	198	190	123	131	190
XM/XMC-95	661	200	192	138	146	210
XM/XMC-100	661	200	192	138	146	210



CCL 'XM' / 'XMC' Systems
Deviation Cone

Annex 19
of ETA-07/0035

Coupler Reducing Cone



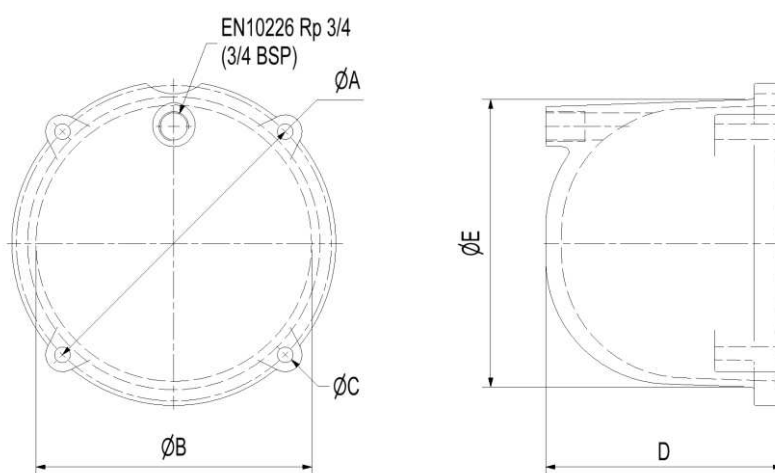
Anchorage	A	ØB	ØC	ØD	ØE	ØF	G
XMC-10	495	220	201	193	48	56	69
XMC-20	517	230	211	203	50	58	70
XMC-30	578	255	236	228	64	72	100
XMC-35	634	280	261	253	74	82	113
XMC-40/45	691	303	284	276	74	82	113
XMC-50	736	320	301	293	84	92	130
XMC-55	759	337	318	310	98	106	150
XMC-60	773	348	329	321	98	106	150
XMC-70	830	400	381	373	98	106	150
XMC-75	883	410	391	383	113	121	175
XMC-80	1173	425	406	398	113	121	175
XMC-90	1249	453	434	426	123	131	190
XMC-95	1269	471	452	444	138	146	210
XMC-100	1269	471	452	444	138	146	210



CCL 'XMC' System
Coupler Reducing Cone

Annex 20
of ETA-07/0035

Sealing Cap



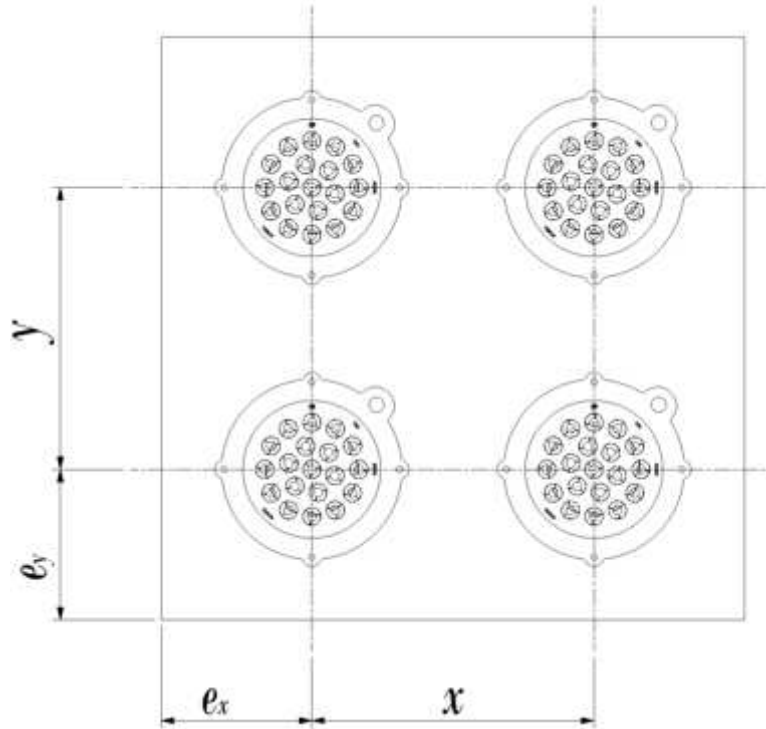
Anchorage	ØA	ØB	ØC	D	ØE
XM-10	-	-	-	-	-
XM-20	-	-	-	-	-
XM-30	-	-	-	-	-
XM-35	210	175	14	160	185
XM-40/45	236	201	14	190	211
XM-50	253	221	14	190	231
XM-55	270	236	14	195	247
XM-60	280	245	14	210	255
XM-70	325	270	18	210	280
XM-75	335	295	18	210	305
XM-80	350	309	18	220	319
XM-90	378	334	18	210	344
XM-95/100	396	348	18	235	361



CCL 'XM' System
Sealing Cap

Annex 21
of ETA-07/0035

Anchorage Spacing and Edge Distances $f_{cm,0}$ on cube 46 MPa



$$A_c = x \cdot y \geq a \cdot b \quad ; \quad x \geq 0.85 a \quad ; \quad y \geq 0.85 b \quad ; \quad e_x = \frac{x}{2} - 10 \text{ mm} + c \quad ; \quad e_y = \frac{y}{2} - 10 \text{ mm} + c$$

Anchorage	$f_{cm,0}$ on cube 46 MPa	
	a	b
XM/XMC-10	200	200
XM/XMC-20	220	220
XM/XMC-30	260	260
XM/XMC-35	300	300
XM/XMC-40	320	320
XM/XMC-45	340	340
XM/XMC-50	360	360
XM/XMC-55	380	380
XM/XMC-60	400	400
XM/XMC-70	430	430
XM/XMC-75	460	460
XM/XMC-80	480	480

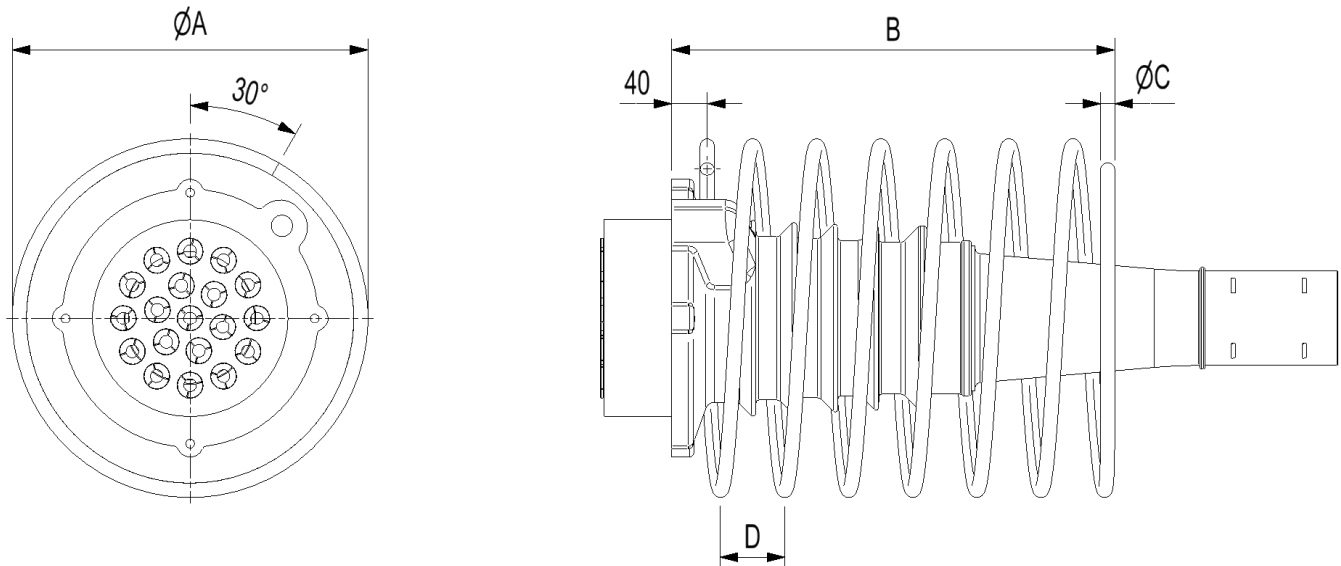
*See Section 1.2.11 for further clarification of the spacing & edge distances e_x , x , e_y & y .



CCL 'XM' / 'XMC' Systems
Anchorage Spacing and Edge Distances
 $f_{cm,0}$ on cube 46 MPa

Annex 33
of ETA-07/0035

Bursting Reinforcement Sizes for Helices $f_{cm,0}$ on cube 46 MPa ($f_{yk} = 500$ MPa)



N = No. of turns in Helix

	$f_{cm,0}$ on cube				
	46 MPa				
Anchorage	ØA	B	ØC	D	N
XM/XMC-10	160	200	8	55	3
XM/XMC-20	170	220	10	50	4
XM/XMC-30	230	260	10	40	5.5
XM/XMC-35	250	300	12	45	6
XM/XMC-40	290	320	12	45	6.5
XM/XMC-45	300	340	16	50	6
XM/XMC-50	315	360	16	50	6.5
XM/XMC-55	340	380	16	50	7
XM/XMC-60	365	400	16	60	6
XM/XMC-70	385	430	16	60	6.5
XM/XMC-75	415	460	16	60	7
XM/XMC-80	445	480	16	65	7

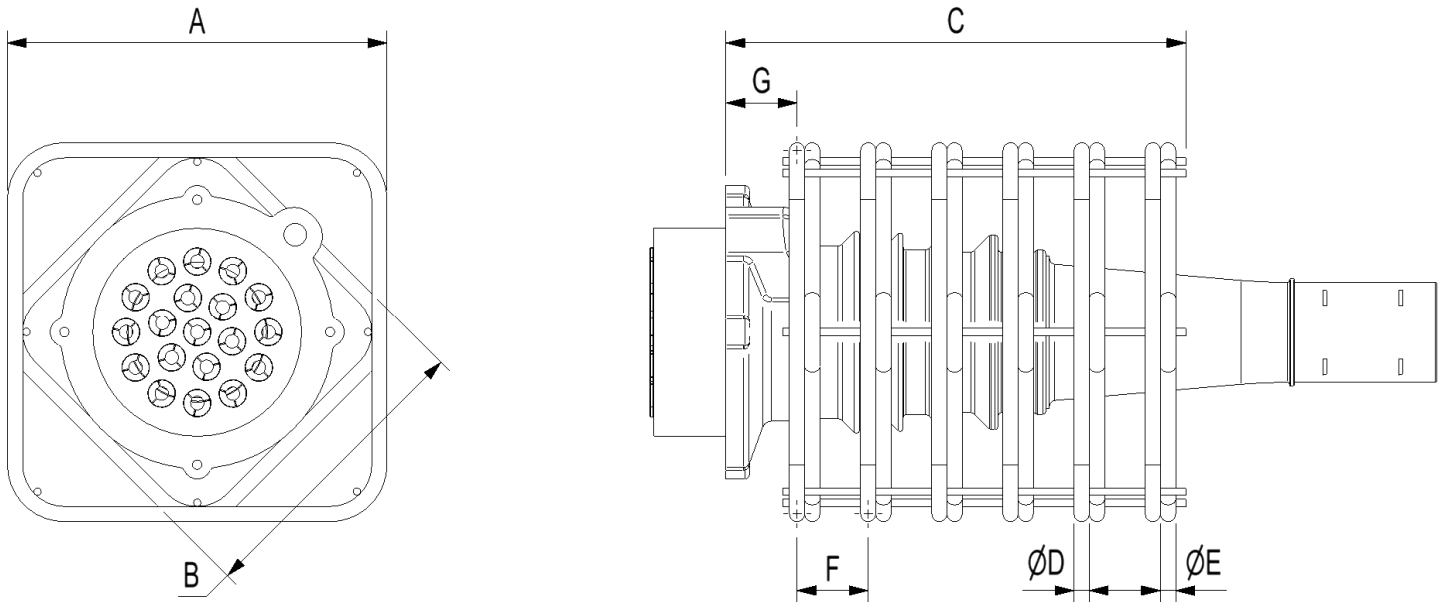
* $f_{yk} = 500$ MPa (Deformed/Ribbed Rebar)



CCL 'XM' / 'XMC' Systems
Bursting Reinforcement Sizes for Helices
 $f_{cm,0}$ on cube 46 MPa ($f_{yk} = 500$ MPa)

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of ETA-07/0035

Bursting Reinforcement Sizes for Links $f_{cm,0}$ on cube 46 MPa ($f_{yk} = 500$ MPa)



N = No. of sets of Links

	$f_{cm,0}$ on cube							
	46 MPa							
Anchorage	A	B	C	ØD	ØE	F	G	N
XM/XMC-10	160	-	200	8	-	75	40	4
XM/XMC-20	170	-	220	10	-	60	40	4
XM/XMC-30	225	175	260	12	10	65	70	4
XM/XMC-35	260	200	300	12	10	65	65	5
XM/XMC-40	300	235	320	12	12	65	75	5
XM/XMC-45	300	230	340	12	12	60	75	6
XM/XMC-50	315	240	360	16	12	80	70	5
XM/XMC-55	345	265	380	16	12	75	80	5
XM/XMC-60	365	275	400	16	12	70	80	6
XM/XMC-70	395	300	430	16	12	70	75	7
XM/XMC-75	425	325	460	16	16	80	90	6
XM/XMC-80	435	335	480	16	16	80	85	6

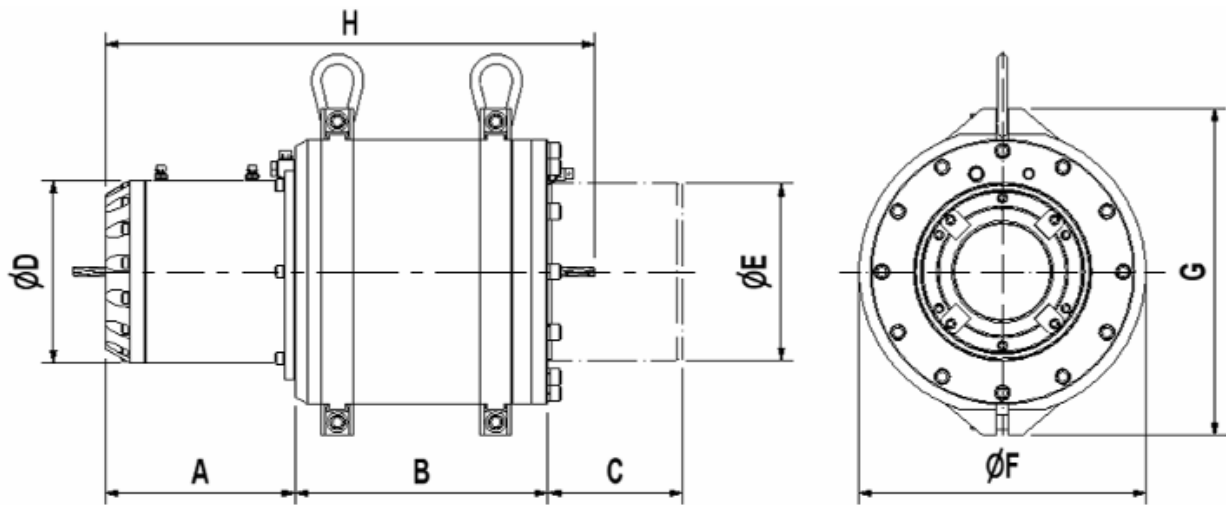
* $f_{yk} = 500$ MPa (Deformed/Ribbed Rebar)



CCL 'XM' / 'XMC' Systems
Bursting Reinforcement Sizes for Links
 $f_{cm,0}$ on cube 46 MPa ($f_{yk} = 500$ MPa)

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of ETA-07/0035

Multistrand Jacks Type 'MG'



Jack Size	A	B	C	ØD	ØE	ØF	G	H min	Weight
1800MG	322	388	220	256	232	360	432	760	275 kg
3000MG	290	388	206	280	270	440	500	700	350 kg
4000MG	307	415	220	344	360	535	585	730	575 kg
6000MG	304	462	214	400	410	622	680	770	700 kg
7500MG	321	480	230	480	490	697	760	850	1150 kg



CCL 'XM' / 'XMC' Systems
Multistrand Jacks Type 'MG'

Annex 36
of ETA-07/0035

Characteristics of the CCL Multistrand Jacks Type 'MG'

1800MG	Maximum Pressure N/mm ²	Area mm ²
Main Ram Extend	44.82	46875
Main Ram Retract	2.06	24732
Lock-Off Ram Extend	27.58	6635
Lock-Off Ram Retract	2.06	5781
Stroke Length	220 mm	

3000MG	Maximum Pressure N/mm ²	Area mm ²
Main Ram Extend	48.61	65391
Main Ram Retract	2.06	33627
Lock-Off Ram Extend	24.13	13974
Lock-Off Ram Retract	2.06	10694
Stroke Length	206 mm	

4000MG	Maximum Pressure N/mm ²	Area mm ²
Main Ram Extend	42.06	102629
Main Ram Retract	2.06	39874
Lock-Off Ram Extend	27.58	17403
Lock-Off Ram Retract	2.06	13634
Stroke Length	220 mm	

6000MG	Maximum Pressure N/mm ²	Area mm ²
Main Ram Extend	47.00	133525
Main Ram Retract	2.06	56609
Lock-Off Ram Extend	27.58	15030
Lock-Off Ram Retract	2.06	15030
Stroke Length	214 mm	

7500MG	Maximum Pressure N/mm ²	Area mm ²
Main Ram Extend	48.61	170901
Main Ram Retract	2.06	57822
Lock-Off Ram Extend	27.58	30030
Lock-Off Ram Retract	2.06	30030
Stroke Length	230 mm	



CCL 'XM' / 'XMC' Systems
Characteristics of the CCL Multistrand Jacks
Type 'MG'

Annex 37
of ETA-07/0035