iBMB MPA TU BRAUNSCHWEIG

Institut für Baustoffe, Massivbau und Brandschutz | Materialprüfanstalt für das Bauwesen

Expert Opinion

- Translation –

Document No.:	(2101/234/18) – CM of 27/07/2018
Client	Index Técnicas Expansivas, S.L. P.I. La Portalada II C. Segador 13 26006 Logroño Spain
Order date:	14/06/2018
Order Ref.:	-
Order received:	14/06/2018
Subject:	Loaded Index injection system MO-H placed in reinforced-concrete members to be assessed for their reaction to fire for determination of the fire resistance time when exposed to a standard temperature-time curve (ETK) fire in accordance with DIN EN 1363-1
Basis for assessment:	See section 1

This Expert Opinion consists of 8 pages, including the cover sheet and 5 annexes.

Materialprüfanstalt f. d. Bauwesen MPA BS 3 Braunschweig

Materialprüfanstalt (MPA)
für das Bauwesen
Beethovenstraße 52
D-38106 Braunschweig

Fon +49 (0)531-391-5400
Fax +49 (0)531-391-5900
info@mpa.tu-bs.de
www.mpa.tu-bs.de

Norddeutsche LB Hannover
IBAN: DE58 2505 0000 0106 0200 50
BIC: NOLADE2H
VAT ID No.: DE183500654
Tax Reg. No.: 14/201/22859

Notified body (0761-CPR) - Approved as a civil engineering testing, inspection and certifying body as well as notified as a civil engineering testing and certifying body.

Table of contents

1 Background and commission ... 2

2 Description of the protection systems ... 3

3 Assessment regarding fire resistance time as a function of the maximum Index injection systems MO-H loading in connection with reinforced-concrete members ... 4
3.1 Assessment regarding fire resistance time as a function of maximum loading in a fire (centric tensile load) ... 4
3.1.1 Load bearing capacity respecting concrete failure / concrete cone failure (centric tensile load) ... 5
3.1.2 Load bearing capacity respecting gaps (centric tensile load) ... 6
3.2 Assessment regarding fire resistance time as a function of maximum loading in a fire (lateral load) ... 6
3.2.1 Load bearing capacity respecting concrete failure (lateral load) ... 7

4 Additional information ... 8

1 Background and commission

With their letter of 14/06/2018, Index Técnicas Expansivas, S.L., Logroño commissioned the MPA Braunschweig to prepare an Expert Opinion for Index injection system MO-H in connection with reinforced concrete members that are subjected to a fire from one side.

The Expert Opinion is based on the tests made for Index injection systems MO-H in connection with reinforced-concrete members, which were exposed to a standard temperature-time curve fire in accordance with DIN EN 1363-1.

The following documents were used as a basis for the Expert Opinion:

[1] DIN EN 1363-1: 2012-10; fire resistance tests – part 1: general requirements
[2] European Technical Report TR 020 : 2004-05, Evaluation of Anchorages in Concrete concerning Resistance to Fire
[3] DIN EN 1992-4, Eurocode 2: Design of concrete structures – Part 4: Design of fastenings for use in concrete; German version prEN 1992-4:2013
[4] Test Report No. (2100/679/15), issued by MPA Braunschweig
[5] Client's technical data sheets for Index injection system MO-H
[6] ETA-14/0138 of 10/05/2018, Index injection system MO-H, issued by the "Technical an Test Institute for Construction Prague", Prague

The Index injection system MO-H are designed on the basis of fire tests that were carried out with uncracked reinforced concrete. The Technical Rules and Regulations and the Technical Specifications, which provide details primarily for mechanical fastenings that are suited under cracked conditions in connection with reinforced-concrete members in a fire, do not yet offer a complete design concept for chemical fastening systems. At the moment, a building code attestation (e.g. ETA) that would provide details for the Index injection system MO-H in the event of a fire is not available. The approvals that are listed above only contain specifications for the normal intended use at normal temperatures.

2 Description of the protection systems

The Index injection system MO-H consist of the injection mortar „MO-H injection mortar" and a anchor rod „MO-H anchor rod" with nuts and washers. The Index injection system MO-H for anchoring in reinforced concrete components primarily under dead load is regulated for the normal purpose of use by European technical application document ETA-14/0138. The injection Index injection systems MO-H (M8 to M30) are made from electrogalvanized steel or stainless steel. The nuts and washers are made from electrogalvanized steel or stainless steel like the anchoring bars. The injection system's mode of action makes use of the bond and forms it between the injection mortar, anchoring bar and base material.

The Index injection systems MO-H were installed according to the installation instructions using the installation tools specified in these documents and relevant tools (heavy - duty hammer drill and drill bit, setting tool and cleaning equipment).

Table 1: Index injection systems MO-H in connection with Index anchor rods (bonded anchor action)

Index injection systems MO-H	Anchor rod dimension (stress cross section A_s [mm])							
Type of anchor rod	M8 (36.60)	M10 (58.00)	M12 (84.30)	M16 (157.00)	M20 (245.00)	M24 (353.00)	M27 (459.00)	M30 (561.00)
Anchor rod (strength class ≥ 4.8)	M8 to M30							
Anchor rod (stainless steel 1.4401, 1.4404, 1.4571, 1.4529)	M8 to M30							

For further details of the systems, reference is made to the annexes, the Index Técnicas Expansivas, S.L., Logroño installation instructions for the Index injection systems MO-H and the ETA [6] listed above.

3 Assessment regarding fire resistance time as a function of the maximum Index injection systems MO-H loading in connection with reinforced-concrete members

The Index injection system MO-H, consisting of the Index injection systems MO-H mortar compound and the steel elements required from case to case (anchor rod, threaded rod), can be assessed for their fire resistance time on the basis of the existing fire performance approvals in connection with reinforced concrete structures.

3.1 Assessment regarding fire resistance time as a function of maximum loading in a fire (centric tensile load)

The above-mentioned systems were assessed for their fire resistance time as a function of maximum loading in a fire (centric tensile load) with respect to system failure (steel failure and bond failure by anchor bar pull-out) on the basis of fire tests that had been performed based on Technical Report TR 020 : 2004-05 in uncracked reinforced concrete. The design values are shown in table 3.1.

$N_{fire(t)}$ ⇒ is the rated value determined for the Index injection system MO-H depending on the function of the fire resistance time. This value considers the steel failure values (section 3.1.1) and pull-out (section 3.1.2).

For the purposes discussed here, the load bearing capacity respecting steel failure describes the resistance of the steel components (anchor bars, threaded bolts) of the Index injection system MO-H under tension in a standard temperature-time curve fire attacking one side of the system in accordance with DIN EN 1363-1: 2012-10. Steel failure becomes decisive as soon as the bond strength of the

Index injection system MO-H exceeds the resistance respecting steel failure. Load bearing capacities beyond the steel failure of the Index injection system MO-H cannot be specified.

The load bearing capacity respecting bond failure (anchor bar pull-out) describes the resistance of the Index injection system MO-H (anchor rod in connection with the mortar) in connection with the reinforced-concrete base (strength classes C20/25 to C50/55) when exposed to tensile loads in a standard temperature-time curve fire attacking one side of the system in accordance with DIN EN 1363-1: 2012-10. The bond strength is influenced by temperature. In the event of a fire, there are temperature gradients along the element anchoring depth. The load bearing capacity of the anchor is limited either by the bond, the concrete or steel failure. From a certain anchoring depth, steel failure can become decisive. Higher load bearing capacities cannot be specified.

Table 3-1: Proposed rating for the Index injection system MO-H (dimension M8 – M30) made from electrogalvanised steel or stainless steel, regarding their fire resistance time as a function of stress σ_s under centric tensile load and the minimum placement depth

designation	Index injection system MO-H							
stress cross section [N/mm²]	36,0	58,0	84,4	157,0	247,0	353,0	459,0	561,0
min. Setting deep [mm]	80	90	110	125	170	210	250	280
fire resistance time **tu**	**max. load** **$N_{fire}(t)$[kN]**							
[min]	**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
30	0,64	0,82	2,23	4,15	6,48	9,33	12,14	14,83
60	0,41	0,57	1,90	3,53	5,51	7,94	10,32	12,62
90	0,19	0,31	1,56	2,91	4,54	6,54	8,51	10,40
120	0,08	0,18	1,40	2,60	4,06	5,85	7,60	9,29

For the normal intended use, loads resulting from the ETA [6] may be decisive.

3.1.1 Load bearing capacity respecting concrete failure / concrete cone failure (centric tensile load)

For the purposes discussed here, the load bearing capacity respecting concrete failure describes the resistance of the Index injection system MO-H in connection with the reinforced-concrete base (strength classes C20/25 to C50/55) as a function of the position and installation of the anchors under tension in a standard temperature-time curve fire attacking one side of the system in accordance with

DIN EN 1363-1: 2012-10. Concrete failure becomes decisive, as soon as the load-bearing capacity of the base, in connection with the fastening means, is no longer adequate.

It is recommended to demonstrate the resistance against the failure mode "concrete cone failure" on the basis of DIN EN 1992-4, Annex D (informative).

Length of fire exposure ≤ 90 minutes:

$$N^0_{RK,p,fire(90)} = h_{ef}/200 \times N^0_{RK,p(90)} \leq N^0_{Rk,p}$$

Length of fire exposure ≥ 90 ≤ 120 minutes:

$$N^0_{RK,p,fire(120)} = 0.8 \times h_{ef}/200 \times N^0_{Rk,p(120)} \leq N^0_{Rk,p}$$

h_{ef} ⇒ effective anchoring depth of the Index injection system MO-H in accordance with ETA [6].

$N^0_{Rk,p}$ ⇒ initial value of the characteristic resistance of the Index injection system MO-H in accordance with ETA [6]. The characteristic load bearing capacity for bonded anchors in accordance with [3] is in this case determined for the normal intended use with the failure combination concrete cone failure and pull-out ($N^0_{Rk,p}$), consideration given to the characteristic bond strength τ_{RK}.

If fastenings are located near edges in a fire, the critical centre / edge distance has to be accounted for with $s_{cr,N} = 2c_{cr,N} = 4h_{ef}$ for concrete failure. Additional parameters (geometry, spalling, eccentricity, position within the member and other influencing factors) may have to be separately accounted for.

3.1.2 Load bearing capacity respecting gaps (centric tensile load)

Verification respecting gaps (without fire exposure) is made on the basis of the building code approvals ([6]). Up-to-date technical standards do not require any verification under conditions of a fire, because it is assumed that the reinforcement will take the gap forces.

3.2 Assessment regarding fire resistance time as a function of maximum loading in a fire (lateral load)

The fire resistance time as a function of maximum loading in a fire (lateral load) of the systems described above was determined on the basis of section 3.1, assuming that

$$V_{fire(t)} = N_{fire(t)}$$

applies. In addition, proof regarding concrete failure has to be established in accordance with section 3.2.2

$V_{fire(t)}$ ⇒ is the rated value determined for the Index injection system MO-H depending on the function of the fire resistance time.

3.2.1 Load bearing capacity respecting concrete failure (lateral load)

For the purposes discussed here, the load bearing capacity respecting concrete failure describes the characteristic resistance of the Index injection system MO-H in connection with the reinforced-concrete base (strength classes C20/25 to C50/55) as a function of the position and installation of the anchors under tension in a standard temperature-time curve fire attacking one side of the system in accordance with DIN EN 1363-1: 2012-10.

Concrete failure becomes decisive, as soon as the load-bearing capacity of the base, in connection with the fastening means, is no longer adequate and/or the required fire resistance time of the reinforced-concrete structure can no longer be complied with.

3.2.1.1 Resistance respecting concrete failure / rear-end concrete cone failure under lateral loads

It is recommended to demonstrate the resistance against the failure mode "rear-end concrete cone failure" on the basis of DIN EN 1992-4, Annex D (informative).

$$V^0_{Rk,cp,fire(90)} = k \times N_{Rk,p,fire(90)}$$

$$V^0_{Rk,cp,fire(120)} = k \times N_{Rk,p,fire(120)}$$

k value ⇒ coefficient for the Index injection system MO-H in accordance with ETA [6].

$N_{Rk,p,fire(90)}$ ⇒ see section 3.1.1

Additional parameters (geometry, spalling, eccentricity, position within the member and other influencing factors) may have to be separately accounted for.

Resistance respecting concrete failure / concrete edge failure (lateral load)

It is recommended to demonstrate the resistance against the failure mode "concrete edge failure" on the basis of DIN EN 1992-4, Annex D (informative).

$$V^0_{Rk,c,fire(90)} = 0.25 \times V^0_{Rk,c}$$

$$V^0_{Rk,c,fire(120)} = 0.20 \times V^0_{Rk,c}$$

$V^0_{Rk,c}$ ⇒ initial value of the characteristic resistance of the Index injection system MO-H in reinforced concrete in accordance with ETA [6]. $V^0_{Rk,c}$ can be determined in accordance with TR029 or DIN EN 1992-4.

Additional parameters (geometry, spalling, eccentricity, position within the member and other influencing factors) may have to be separately accounted for.

4 Additional information

4.1 This Expert Opinion does not replace the required building code attestation (Building Code Test Certificate, National Technical Approval, ETA).

4.2 The above assessment only applies to Index injection system MO-H in connection with uncracked reinforced-concrete members, due regard given to the conditions specified in the client's technical data sheets.

4.3 The assessment for the Index injection system MO-H only applies in connection with reinforced-concrete systems that are subjected to a fire from one side, and that can at least be classified into the fire resistance class that corresponds to that of the injection system.

4.4 The rating of the Index injection system MO-H relates to the fastening means in connection with reinforced-concrete members that are subjected to a standard temperature-time curve fire in accordance with DIN EN 1363-1: 2012-10 from one side. When more than one side are exposed to a fire of max. 90 minutes, the rated values may be applied only, if the steel failure becomes decisive, the fire resistance class of the reinforced-concrete base (strength classes C20/25 to C50/55) is not adversely affected, and a distance of $c \geq 300$ mm and $c \geq 2h_{ef}$ is maintained between the Index injection system MO-H and the edge.

4.5 The validity of this Expert Opinion will expire on 27/07/2023.

This document is a translated version of Expert Opinion 2101/234/18-CM dated 27/07/2018. The legally binding text is the aforementioned German Expert Opinion.

i.A.
ORR Dr.-Ing. Blume
Deputy Head of Department

Materialprüfanstalt f. d. Bauwesen
MPA
BS
3
Braunschweig

i.A.
Dipl.-Ing. Maertins
Official/engineer in charge

Threaded rod

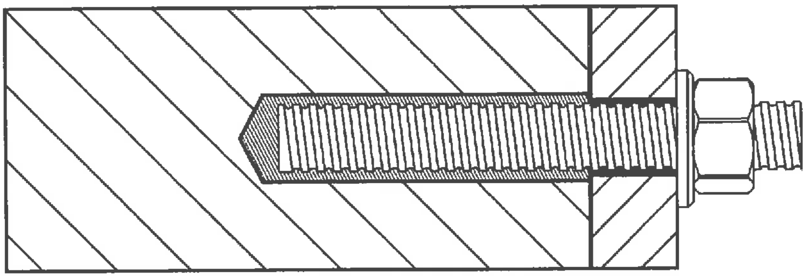


Table 2: technical data

Size			M8	M10	M12	M16	M20	M24	M27	M30
Nominal drill hole diameter	$Ød_0$	[mm]	10	12	14	18	22	26	30	35
Diameter of cleaning brush	d_b	[mm]	14	14	20	20	29	29	40	40
Torque moment	max T_{fix}	[Nm]	10	20	40	80	150	200	240	275
Depth of drill hole for $h_{ef,min}$	$h_0 = h_{ef}$	[mm]	64	80	96	128	160	192	216	240
Depth of drill hole for $h_{ef,max}$	$h_0 = h_{ef}$	[mm]	160	200	240	320	400	480	540	600
Minimum edge distance	c_{min}	[mm]	35	40	50	65	80	96	110	120
Minimum spacing	s_{min}	[mm]	35	40	50	65	80	96	110	120
Minimum thickness of member	h_{min}	[mm]	h_{ef} + 30 mm ≥ 100 mm				$h_{ef} + 2d_0$			

Table 3: technical data

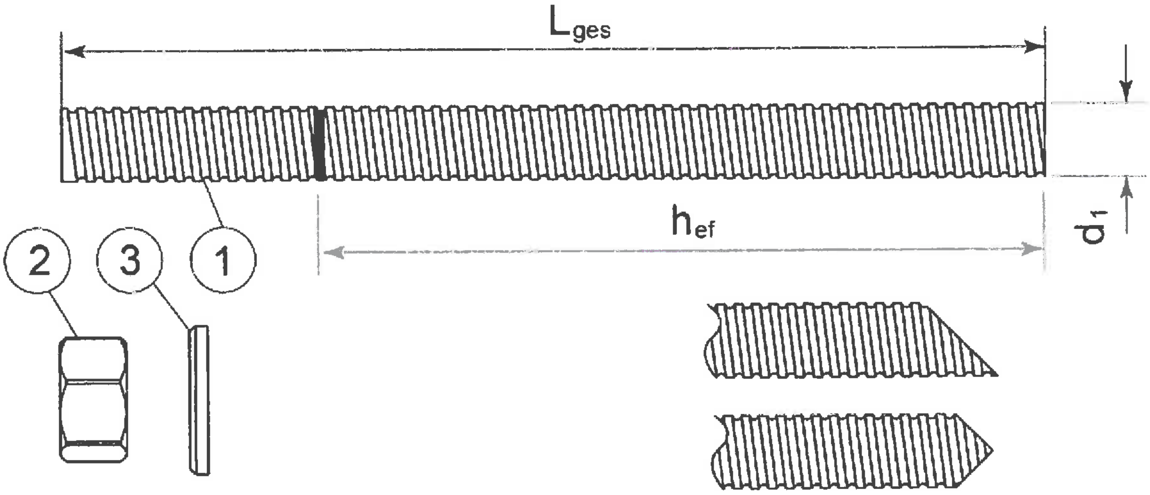
Application temperature	Processing time	Load time
+5 to +10°C	10 mins	145 mins
+10 to +15°C	8 mins	85 mins
+15 to +20°C	6 mins	75 mins
+20 to +25°C	5 mins	50 mins
+25 to +30°C	4 mins	40 mins

Processing time refers to the highest temperature in the range.
Load time refers to the lowest temperature in the range.
Cartridge must be conditioned to a minimum +5°C.

All diameters
- 2 x blowing
- 2 x brushing
- 2 x blowing
- 2 x brushing
- 2 x blowing

Index injection system MO-H: Threaded rod with washer and hexagon nut

Threaded rod M8, M10, M12, M16, M20, M24, M27, M30

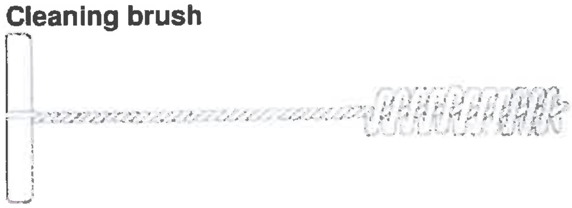


Standard commercial threaded rod with marked embedment depth

1. Threaded rod, 2. washer, 3. hexagon nut

Index injection system MO-H „Cleaning brush"

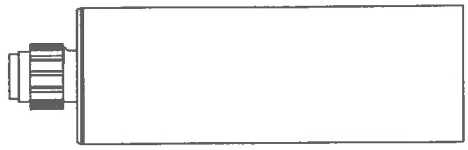
Cleaning brush



Index injection system MO-H: “injection mortar”

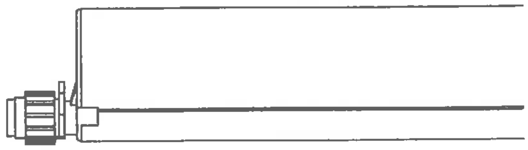
Coaxial cartridge
MO-H:

150 ml
380 ml
400 ml
410 ml



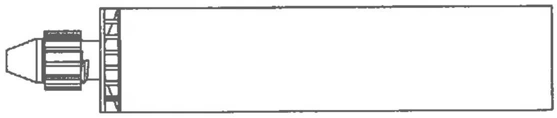
Side-by.side“ cartridge
MO-H:

350 ml
825 ml



Two part foil in a songle pistion component cartridge
MO-H:

150 ml
170 ml
300 ml
550 ml
850 ml



Peeler cartridge
MO-H:

280 ml

Marking of the mortar cartridges
Identifying mark of the producer, trade name, Charge code number, Storage life, Curing and processing time

Index injection system MO-H: „mixing nozzle“

Mixing nozzle

KW

RC

RM

TB

KR for use with 850

Installation instruction [6]

Base materials

- Non-cracked concrete.
- Cracked and non-cracked concrete for threaded rod size M10, M12, M16, M20, M24
- Reinforced or unreinforced normal weight concrete of strength class C20/25 at minimum and C50/60 at maximum according EN 206-1:2000-12.

Temperature range:

- -40°C to +80°C (max. short. term temperature +80°C and max. long term temperature +50°C)

Use conditions (Environmental conditions)

- Structures subject to dry internal conditions (zinc coated steel, stainless steel, high corrosion resistance steel).
- Structures subject to external atmospheric exposure including industrial and marine environment, if no particular aggressive conditions exist (stainless steel, high corrosion resistance steel).
- Structures subject to permanently damp internal condition, if no particular aggressive conditions exist (stainless steel, high corrosion resistance steel).
- Structures subject to permanently damp internal condition, with particular aggressive conditions exist (high corrosion resistance steel).

Note: Particular aggressive conditions are e.g. permanent, alternating immersion in seawater or the splash zone of seawater, chloride atmosphere of indoor swimming pools or atmosphere with extreme chemical pollution (e.g. in desulphurization plants or road tunnels where de-icing materials are used).

Use categories:

- Category 2 – installation in dry or wet concrete or in flooded hole.

Design:

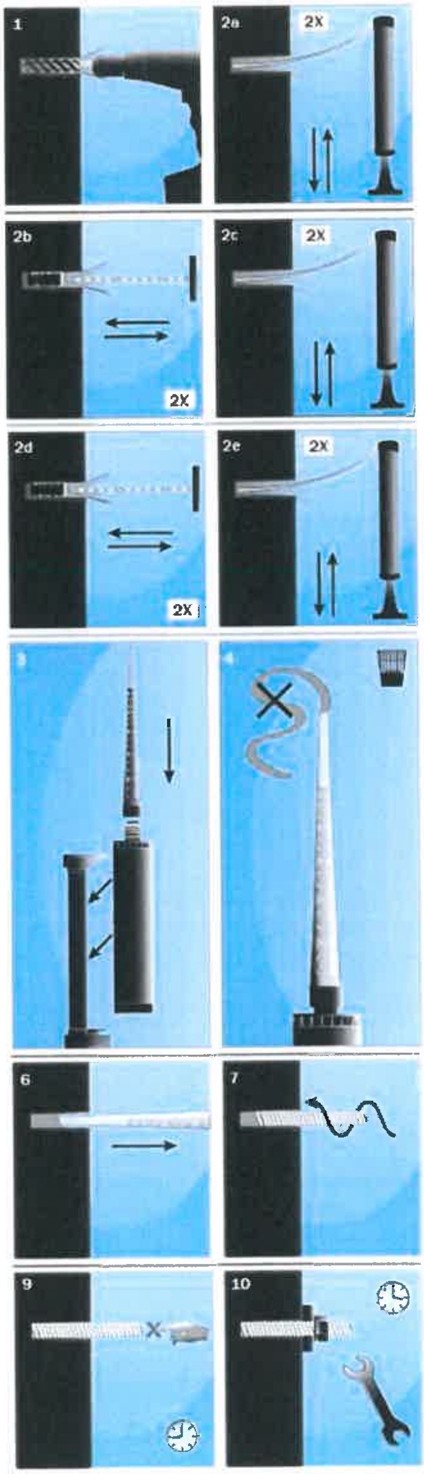
- The anchorages are designed in accordance with the EOTA Technical Report TR 029 "Design of bonded anchors" under the responsibility of an engineer experienced in anchorages and concrete work.
- Verifiable calculation notes and drawings are prepared taking account of the loads to be anchored. The position of the anchor is indicated on the design drawings.
- Anchorages under seismic actions (cracked concrete) have to be designed in accordance with EOTA Technical Report TR 045 "Design of Metal Anchors under Seismic Action".

Installation:

- Dry or wet concrete or flooded hole.
- Hole drilling by hammer drill mode.
- Anchor installation carried out by appropriately qualified personnel and under the supervision of the person responsible for technical matters of the site.

Installation instruction [6]

Installation instructions



1. Drill the hole to the correct diameter and depth using a rotary percussion drilling machine.

2. Thoroughly clean the hole in the following sequence using the Brush with the required extensions and a blow pump:

   Blow Clean x2.
   Brush Clean x2.
   Blow Clean x2.
   Brush Clean x2.
   Blow Clean x2.

   Remove standing water from the hole prior to cleaning to achieve maximum performance.

3. Select the appropriate static mixer nozzle for the installation, open the cartridge/cut foil pack and screw nozzle onto the mouth of the cartridge. Insert the cartridge into a good quality applicator (gun).

4. Extrude the first part of the cartridge to waste until an even colour has been achieved without streaking in the resin.

5. If necessary, cut the extension tube to the depth of the hole and push onto the end of the mixer nozzle, and fit the correct resin stopper to the other end.

6. Insert the mixer nozzle (or the extension tube with resin stopper when necessary) to the bottom of the hole. Begin to extrude the resin and slowly withdraw the mixer nozzle from the hole ensuring that there are no air voids as the mixer nozzle is withdrawn. Fill the hole to approximately ½ to ¾ full and withdraw the nozzle completely.

7. Insert the clean threaded bar, free from oil or other release agents, to the bottom of the hole using a back and forth twisting motion ensuring all the threads are thoroughly coated. Adjust to the correct position within the stated working time.

8. Excess resin will be expelled from the hole evenly around the steel element showing that the hole is full.
   This excess resin should be removed from around the mouth of the hole before it sets.

9. Leave the anchor to cure.
   Do not disturb the anchor until the appropriate loading time has elapsed depending on the substrate conditions and ambient temperature.

10. Attach the fixture and tighten the nut to the recommended torque.
    Do not overtighten.