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| <i>Change Log</i> | | | |
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| Engineering Technical Documentation - PBS 62.11/14/74 - Tokamak Complex - Post-Drilled Anchors (PDA) Qualification - PDA Catalog - ENG_51_TR_110031_CW (8Z8HNP) | | | |
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Engineering Technical Documentation - PBS 62.11-14-74 Tokamak Complex - Post Drilled Anchors (PDA) Qualification - PDA Catalogue

Brief description:

This document aims to define the Post Drilled Anchors (PDA) catalogue of PDA products, which meet the ITER project technical requirements for use within the Tokamak Complex.

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1. INTRODUCTION

According to OS #680 [11], ENGAGE was requested to establish a documentation baseline meant to frame the Qualification process for Post-drill anchors (PDA) within the Tokamak Complex (TKC). This Program will also cover the entire PDA engineering cycle from design to Implementation in order to ensure the Selection, Design and Implementation of qualified PDA products within the TKC.

The PDA qualification program articulates in 3 phases as per presented in the diagram below:

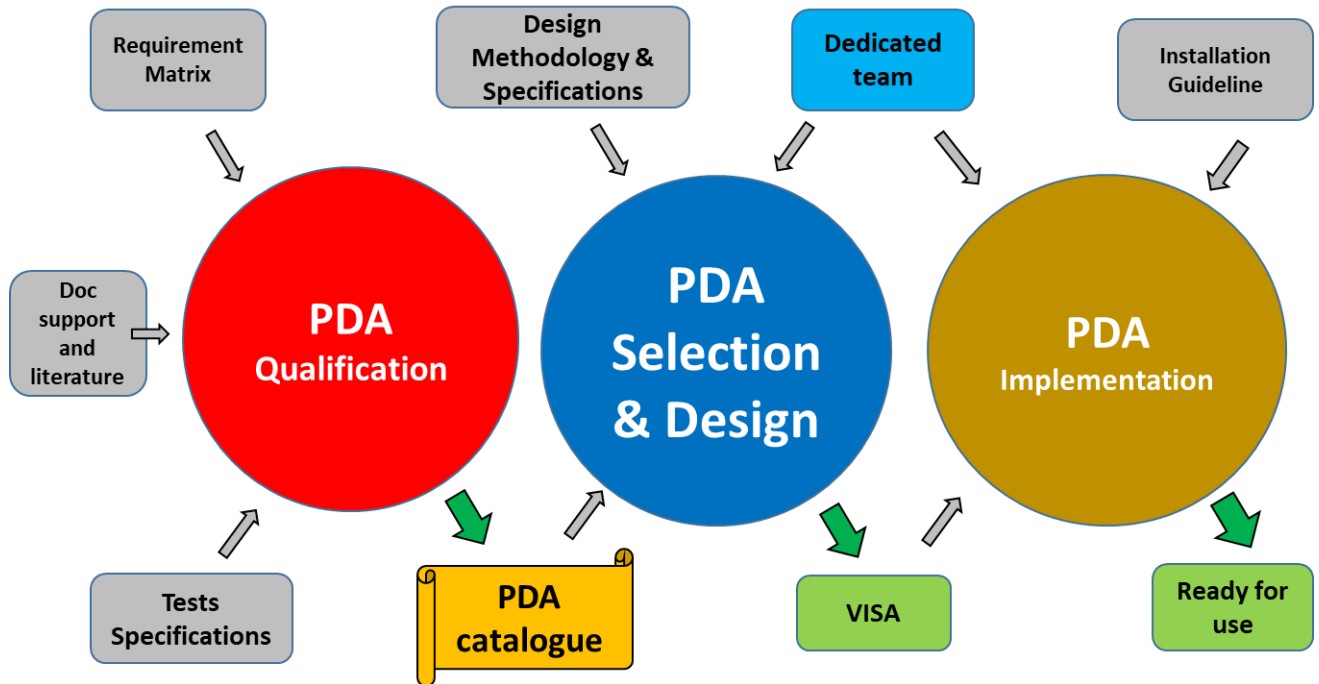


Figure 1 - PDA Qualification Program Phases

- **PDA Qualification:** This phase aims to frame the Qualification of PDA Products for use in the TKC. The outcome of such a phase is the PDA catalogue that references all PDA products qualified for use in the TKC.
- **PDA Selection & Design:** This phase aims to frame the selection of PDAs from the PDA catalogue & their design (construction design) in consideration of the whole PDA design context (Equipment type/location / Load Type) in the way that ITER Project PDA qualification intents are maintained (Preservation of structural integrity of TKC Reinforced concrete structure and preservation of fastening systems load capacity).
- **PDA Implementation:** This phase aims to frame the Installation of PDAs in the way that ITER Project PDA qualification intents are maintained (*Preservation of structural integrity of TKC Reinforced concrete structure and preservation of fastening systems load capacity*).

The flowchart hereunder gives a more detailed overview of the PDA qualification program:

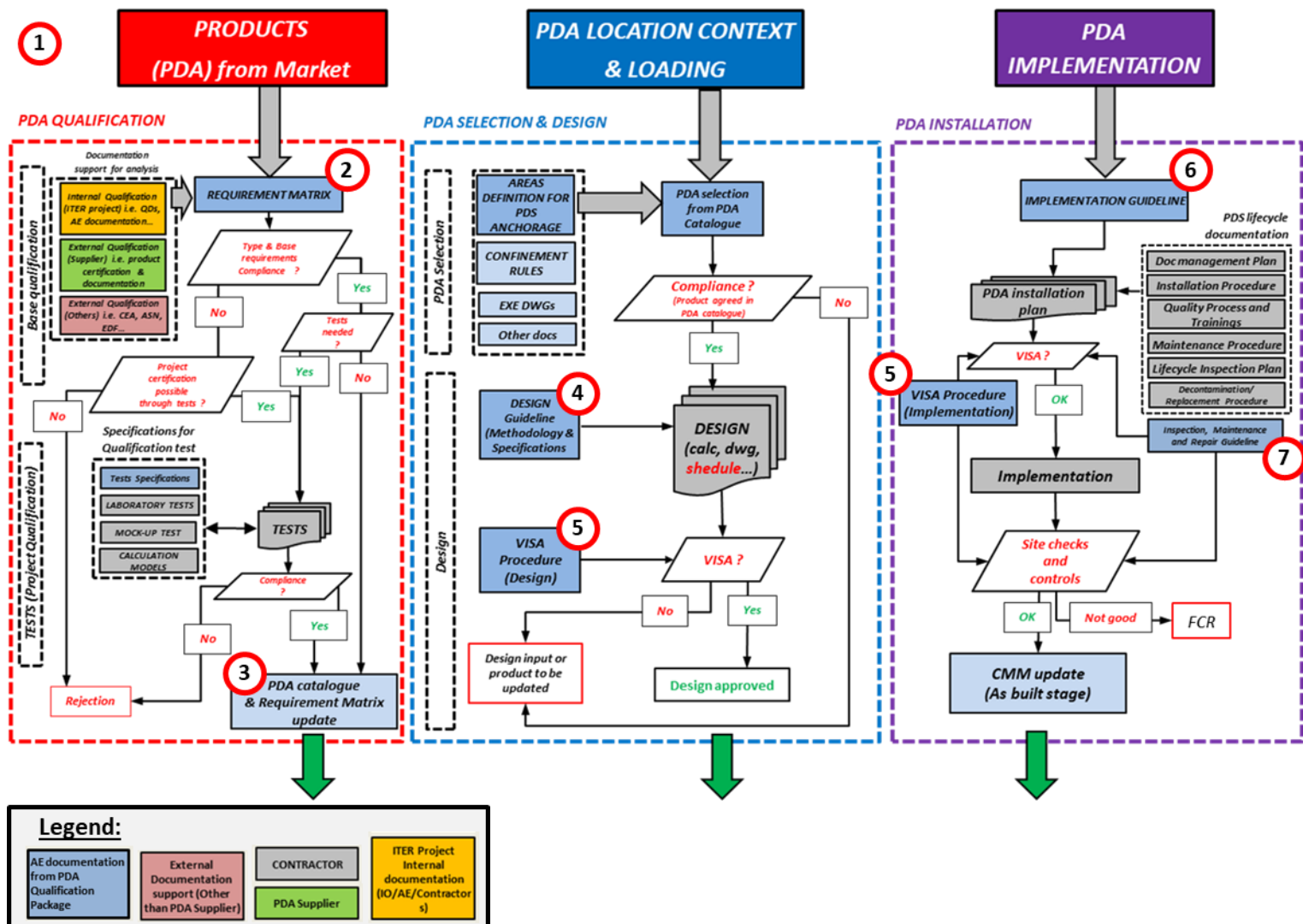



Figure 2 - Detailed PDA Qualification Program

The PDA qualification program documentation baseline is framed by the set of ENGAGE documents that are described hereunder:

- 1) **ENG-04-PZ-110001-CW [1]– PDA Qualification Program Global Procedure:** This document defines the general procedure and scope of the PDA qualification program for the qualification/design and installation of PDA within the TKC.

The qualification of the PDA products within the TKC is framed by the following ENGAGE documents:

- 2) **ENG-51-TR-110029-CW [2] – PDA Requirement matrix:** This document defines the base and scenario-specific requirements applicable to PDA products that are to be implemented in the TKC.
- 3) **ENG-51-TR-110031-CW [3] – PDA Catalogue:** This document references the list of PDA products that comply with the defined ITER project requirements and that are thus qualified for use within the TKC.


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|  | <p style="text-align: center;">ENG-51-TR-110031-CW-v03.0</p> <p style="text-align: center;">Engineering Technical Documentation – Tokamak Complex – PBS 62.11-14-74 - Post-Drilled Anchors (PDA) Qualification - PDA Catalogue</p> | <p style="text-align: right;">Page 7 of 17</p> |
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The selection and design of TKC PDA qualified products are framed by the following ENGAGE documents:

- 4) **ENG-51-TR-110030-CW [4] – PDA Design Methodology Guideline:** This document describes the design methodology applicable for PDA qualified products to be installed in TKC.
- 5) **ENG-04-PZ-110002-AL [5] – PDA VISA Procedure:** This document describes the VISA activities related to PDA Design and Implementation phases for PDA to be installed in the TKC. (*document applicable to both, Selection/Design & Implementation phases*).

The implementation and maintenance stages for PDA products are framed by the following ENGAGE documents:


- 6) **ENG-54-SP-110003-CW [6] – PDA Implementation guideline:** This document defines the technical specifications applicable for the implementation stage of PDA within the TKC.
- 7) **ENG-70-SP-110001-CW [7] – PDA Inspection, Maintenance & Repair guideline:** This document defines the technical specifications applicable along inspection, maintenance and repair activities after PDA installation.

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2. SCOPE


The purpose of this document is to compile a shortlist of pre-qualified Post Drilled Anchors (PDA) for use in the Tokamak Complex (TKC) that potentially meet the ITER project technical requirements [2]). The designer will be required to select an appropriate product from this shortlist for their specific design. The completed PDA catalogue is provided in Appendix 1, the rest of the document records the process followed in compiling the catalogue and rationale behind the decisions made.

It should be noted that the Tokamak Complex is a Nuclear facility which needs to comply with nuclear safety requirements. Particularly, post drilling in confinement barrier concrete member may increase the risk for loss of confinement due to local reductions of concrete member thickness and capacity. Hence it is recommended that post-drilling is performed only if there is no other feasible solution possible than drilling. In any case, all justifications that the implementation of such a solution complies with the established safety requirements must be brought and duly recorded in compliance with the adequate qualification process.

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3. REFERENCES

| <u>Doc SGTI reference numbers</u> | Version | Title | Used | Description the document |
|---|---------|---|-----------|---|
| [1] ENG_04_PZ_110001_CW IO IDM: ITER_D_ 8ZN4TE | 02.0 | Quality Procedure - PBS62.11-14-74 Tokamak Complex - Post Drilled Anchors (PAD) Qualification Procedure | Mentioned | PDA Qualification Program |
| [2] ENG_51_TR_110029_CW IO IDM: ITER_D_UNQSQ6 | 02.0 | Engineering Technical Documentation – Tokamak Complex – PBS 62.11-14-74 – Post-Drilled Anchors Requirement Matrix | Mentioned | PDA requirement matrix |
| [3] ENG_51_TR_110031_CW IO IDM: ITER_D_ 8Z8HNP | 03.0 | Engineering Technical Documentation – Tokamak Complex – PBS 62.11-14-74 – Post-Drilled Anchors Catalogue | Mentioned | PDA Catalogue |
| [4] ENG_51_TR_110030_CW IO IDM: ITER_D_ 8Z88AT | 02.0 | Engineering Technical Documentation - PBS 62.11-14-74 Tokamak Complex - Post-drilled Anchors Design Methodology | Mentioned | PDA Design Methodology – Current Document |
| [5] ENG_04_PZ_110002_AL IO IDM: ITER_D_ 8ZN6F3 | 02.0 | Quality Procedure - PBS62.11-14-74 Tokamak Complex - Post Drilled Anchors (PAD) Design and Implementation VISA Procedure | Mentioned | PDA VISA |
| [6] ENG_54_SP_110003_CW IO IDM: ITER_D_ 93MLJW | 02.0 | Execution Design - PBS62.11-14-74 Tokamak Complex - Post Drilled Anchors (PDA) Implementation Guideline | Mentioned | PDA Implementation |
| [7] ENG_70_SP_110001_CW IO IDM: ITER_D_ 93MMMM | 02.0 | Post Drilled Anchors (PDA) - PBS62.11-14-74 Tokamak Complex - Inspection, Maintenance and Repair Guideline | Mentioned | PDA Maintenances Guideline |
| [8] EN 1992-4:2018 | - | Eurocode 2 - Design of concrete structures Part 4: Design of fastenings for use in concrete, 09/03/2018 | Mentioned | Given for information |
| [9] EAD 330232-00-0601 | - | Mechanical Fasteners for Use in Concrete, EOTA, 2016 | Mentioned | Given for information |
| [10] RCC-CW 2019 | - | Civil Design and execution rules for Nuclear Power Plants, AFCEN, 2019 | Mentioned | Given for information |
| [11] ENG_83_OS_CN0680_AL IO IDM: ITER_D_2WD2KQ | 01.0 | F4E-2009-OPE-058-OS680_- Notification 2022/007 development of Post Drilling System Qualification for Concrete to Buildings with Nuclear Safety Requirements | Mentioned | Order of service for PDA qualification activity |
| [12] ENG_06_ME_111469_CW | 02.0 | TKC PDA Qualification - Leak Rate Assessment of TKC Confinement Zones After Post-Drill Anchor Installation | Mentioned | Leak Rate Assessment after post-drilling |
| [13] ITER_D_FF92TR | 02.0 | List Safety Defined Requirements (QDs) for Site & Buildings (PBS 61, 62, 63, 65) of ITER Nuclear Facility | Mentioned | QDs for TKC |
| [14] ITER_D_2E4KSJ | 4.10 | Safety Requirements for ITER Facility Buildings | Mentioned | Safety Requirements |

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4. ABBREVIATIONS

| | | |
|-------------|---|---|
| COTS | : | Commercial off the shelf |
| EAD | : | European Assessment Document |
| EC | : | Eurocode |
| EOTA | : | European Organisation for Technical Approvals |
| ETA | : | European Technical Assessment |
| FEA | : | Finite Element Analysis |
| TKC | : | Tokamak Complex |
| PDA | : | Post Drill Anchor |

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5. POST DRILL SYSTEM DEFINITION

A Post Drilled System (*PDS*) as per defined for ITER Project use is a fastening system meant to be installed after concreting stages are completed. The implementation of a PDA requires drilling activities to be carried out in the frame of the PDA installation process.

A PDS assembly is composed of the following Items:

- Pre-drilled **Plate**
- **Post Drilled Anchors (PDA)** (eventually supplemented by Annular gap infill products based on applicable requirements)

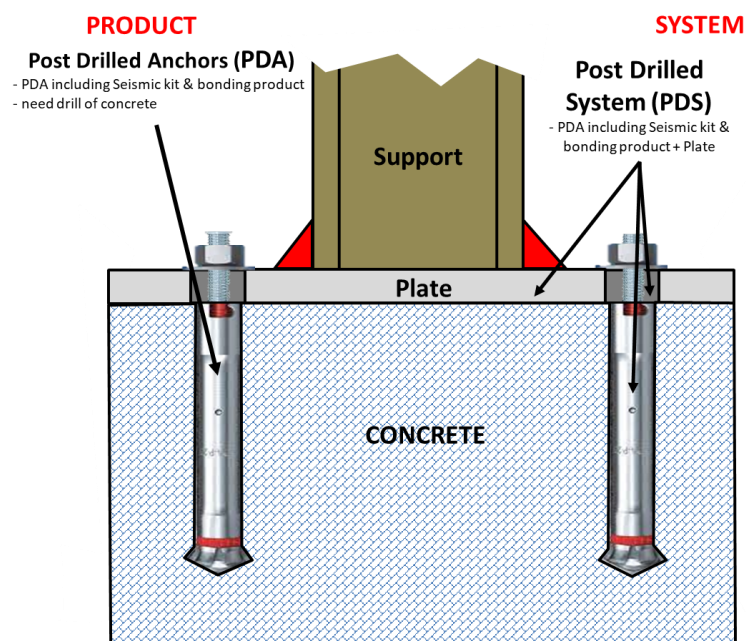



Figure 3 - PDA & PDS Representation

The Post-drilled anchors (PDA) refer to anchors products that can be installed after concreting phase. A hole is drilled into the reinforced concrete and the PDA product is then installed into it.

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|  | <p style="text-align: center;">ENG-51-TR-110031-CW-v03.0</p> <p style="text-align: center;">Engineering Technical Documentation – Tokamak Complex – PBS 62.11-14-74 - Post-Drilled Anchors (PDA) Qualification - PDA Catalogue</p> | <p style="text-align: right;">Page 12 of 17</p> |
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There are various types of PDAs for which some examples are given below.

The two main categories of PDA are as follow:

1) Mechanical PDA:

- **Torque controlled fasteners:** They consist of either sleeve or bolt-type anchors. The anchors' installation is secured by applying a specified torque to the bolt head or nut with a torque wrench. Once the bolt/nut achieves bearing against the base material, the further application of torque draws the cone at the embedded end of the anchor up into the expansion elements against the sides of the drilled hole. A representative figure is given below.

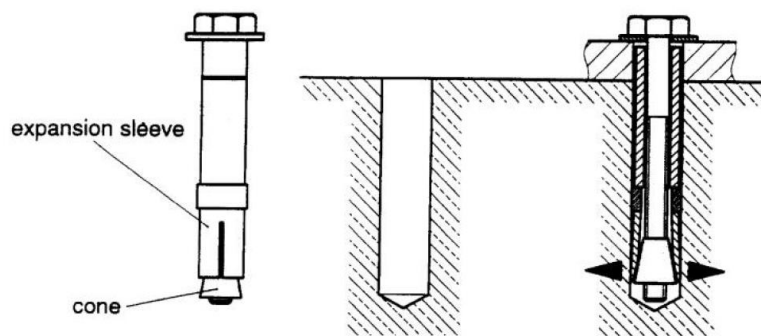


Figure 4 - Example of torque-controlled anchors

- **Undercut fastener:** this type of anchor develops a mechanical interlock between the anchor and base material. To do this, a cylindrically drilled hole is modified to create a notch, or undercut, of a specific dimension at a defined location either by means of special drilling apparatus or by the undercutting action of the anchor itself. A representative figure is given below.

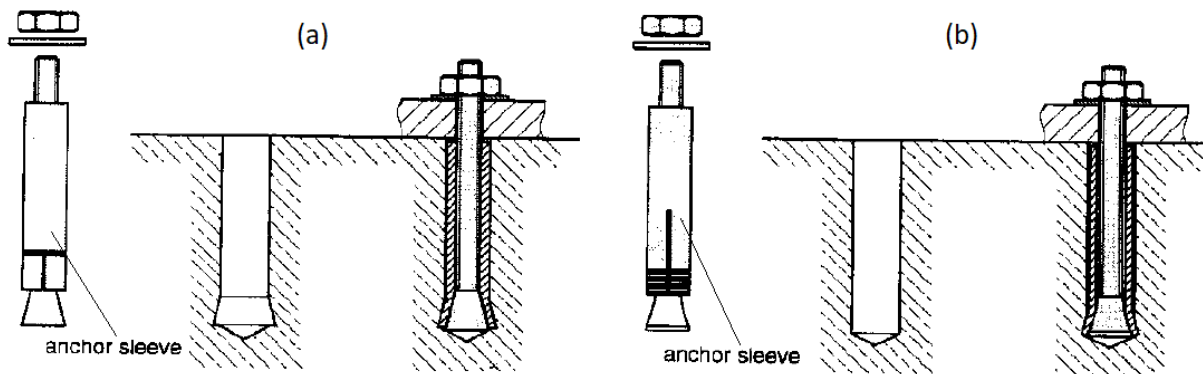



Figure 5 - Example of undercut anchors

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2) Chemical PDA:

- **Bonded anchor (project approval required):** These anchors' anchorage relies on a bonding product (*cementitious product or polymer resin*) that is injected into a drilled hole. Bonded anchors are then installed into the hole and resist by adherence and micro-keying of the bonding product to the anchor rod and to the sides of the drilled hole. Therefore, the tension load capacity of the installed anchor depends significantly on the condition of the drilled hole before installation. A representative figure is given below.

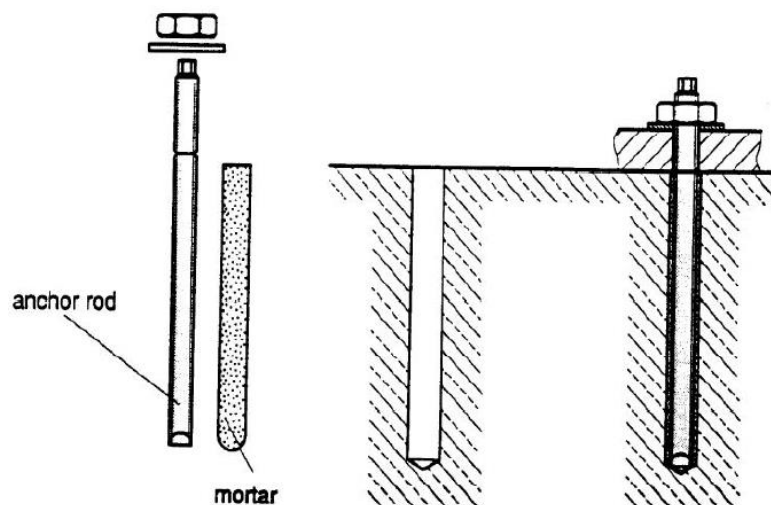



Figure 6 - Example of bonded anchors

It shall be noted that the PDA Qualification program as per presented in section 1 is focused on PDA and not PDS. Thus, Design, Implementation and VISA activities related to the plate part of the PDS are not covered by the documentation listed in section 1. Any mention of the plate part in these documents is only indicative. Nevertheless, it shall also be noted that Design / VISA / Installation activities need to be handled for the plate in order to extend the qualified PDA Design & implementation to qualified PDS Design & implementation.

Design verifications on the plate part and subsequent VISA and installation specifications may be addressed in parallel with the PDA Qualification program.

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6. PDA REQUIREMENTS

PDA products will need to meet the requirements as defined within the Requirements Matrix [2]. These requirements may be split into the following two categories:

Base requirements – Requirements which are applicable to all PDA products to be installed in the Tokamak complex.

Base requirements must be achieved for a PDA product to be included in the PDA catalogue. These requirements have been identified as applicable to “All TKC” from [2].

Scenarios specific requirements – Requirements which are dependent upon the specific design scenario and/or location to which the PDA products shall be installed into.


Scenario specific requirements for PDA products may, or may not, be judged applicable by the PDA designer based on design information of the specific scenario for PDA product selection. These requirements may be identified as “by TKC Zone” or “by Equipment” from [2].

7. PDA CATALOGUE UPDATE

The current PDA catalogue shortlist has been developed using the following approach.

The PDA products available from the key PDA product manufacturers have subsequently been reviewed and the products meeting the base requirements have been identified. Products within this list that have been found to meet the scenario specific requirements have been included in the PDA catalogue. From the remaining products, meeting the base requirements only, the catalogue has been populated with products which cover a range of scenario specific preferences (i.e. the allowable installation types, strength, embedment depth, cost & materials) whilst not arbitrarily increase the number of PDA products included.

The addition of new PDA products to the PDA catalogue shall use a similar approach to that mentioned above, as products to be included in the PDA catalogue will also need to meet the base requirements and checked as to which (if any) scenario specific requirements are met. When new products are added to the PDA catalogue in APPENDIX 1 this document should be revised, and the revision shall be captured in the table in APPENDIX 1.

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|  | <p style="text-align: center;">ENG-51-TR-110031-CW-v03.0</p> <p style="text-align: center;">Engineering Technical Documentation – Tokamak Complex – PBS 62.11-14-74 - Post-Drilled Anchors (PDA) Qualification - PDA Catalogue</p> | <p style="text-align: right;">Page 15 of 17</p> |
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8. SELECTION OF PDA PRODUCTS FOR DESIGN

This section will consider the process a designer will need to undertake to select a product from the PDA catalogue.

The PDA catalogue has been created by using the ITER PDA requirement matrix [2] depending on base & scenario specific requirements. All the products presented in catalogue (APPENDIX 1) comply with the base requirements from [2]. Thus, the PDA catalogue provides several options when scenario specific requirements (seismic, fatigue and fire) from [2] are applicable. The presented products from catalogue shall be chosen depending on the needs (TKC zoning, loading conditions) and shall be justified by using the design methodology defined in [4].


It should be noted that the pre-selected products have been assessed against confinement requirements as defined by ITER Codes [13] in ENGAGE memorandum [12] and no associated increase in leak rate beyond the permissible limits proposed in [14] has been detected among the products presented in the catalogue. Therefore, all the products presented in APPENDIX 1 are pre-qualified for confinement requirements. In the case of any future additions to the catalogue (APPENDIX 1), if the PDA product parameters (type, diameter, drill depth, anchor spacing) are out of the presented range (APPENDIX 1), the admissibility of the product should be proven against determined TKC leak rate limits by IO [14].

The designer will need to determine the applicable scenario-specific requirements for the PDA products to be used for their design. This requires the designer to identify if their design is expected to need resistance under fire conditions and/or if the PDA product is expected to have specific fatigue loading conditions. These parameters require inputs such as the location of the PDA product, loading conditions or design constraints.

If the PDA product must be subject to fatigue loading only the products with an 'X' within the 'Fatigue loading' column of the PDA catalogue may be selected (i.e. PDA Product No's 4, 6 and 8).

If the PDA product is expected to be required to resist REI120 fire condition only the products with either an 'X' within the 'Fire reaction A1 & Fire resistance REI120' column of the PDA catalogue may be selected (i.e. PDA Product No's 1, 2, 3, 4, 5, 6, 7, 8, 9, 12, 13, 14 and 15). It is noted that some products will require additional design calculations to EN 1992-4 [2] to achieve this requirement.

From the resulting PDA products, the designer is required to select an appropriate product for their design based on scenario specific preferences (i.e. strength, embedment depth, cost & materials) and check if the selected products meet requirements not applicable to PDA selection by the PDA catalogue (i.e. radiological and contamination requirements).

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9. PDA CATALOGUE HEADINGS

This section outlines the headings of the columns used in the PDA catalogue in APPENDIX 1.

| <u>Column Heading</u> | <u>Description</u> |
|--|---|
| No. | Identifying number of the PDA product within the catalogue. |
| Manufacturer | Manufacturer of the PDA product. |
| Name | Name of the PDA product. |
| Steel Grade | Steel grade of the PDA product. |
| Type | Type of post-installed fastener. |
| ETA Reference | Number of relevant ETA certifications for the product. |
| Diameter | Diameter of the PDA product. |
| Required Drill Hole Depth | The drill hole depth required to install the PDA of all applicable diameters in the hardened concrete structure. This is provided for the lower anchor embedment and greatest anchor embedment depth if applicable for information. |
| Seismic Classification C2 | This parameter will be marked with an “X” if the PDA product is qualified for seismic loading to classification C2. |
| Fatigue Loading | This parameter will be marked with an “X” if the PDA product is qualified for fatigue loading. |
| Fire reaction A1 & Fire resistance REI120 | This parameter will be marked with an “X” if the PDA product is qualified to the scenario-specific requirement #S4. |

| No. | Manufacturer | Name | Steel Grade | Type | ETA Reference | Diameter (D0) (mm) | Required Drill Hole Depth (hdrill from manufacturer catalogues – given for information) | | Nuclear Safety - Confinement ² | Seismic Classification C2 | Fatigue Loading | Fire Reaction A1 & Fire Resistance REI120 |
|---|--------------|----------------------|--------------------------|------------------------------------|--------------------------|-----------------------|--|-------------------------------|---|---------------------------|-----------------|---|
| | | | | | | | Lower Anchor Embedment (mm) | Greater Anchor Embedment (mm) | | | | |
| 1 | HILTI | HST3 | Zinc plated carbon steel | Torque controlled expansion bolt | ETA-98/0001 | 8/10/12/16/20 | 69/73/88/106/124 | 102/113/143/181/203 | X | X | - | X |
| 2 | HILTI | HST3-R | Stainless steel | Torque controlled expansion bolt | ETA-98/0001 | 8/10/12/16/20 | 69/73/88/106/124 | 102/113/143/181/203 | X | X | - | X |
| 3 | HILTI | HSL4-G | Zinc plated carbon steel | Torque controlled expansion sleeve | ETA-19/0556 | 10/12/16 | 90/105/180 | 130/155/240 | X | X | - | X |
| 4 | HILTI | HSL4-G | Zinc plated carbon steel | Torque controlled expansion sleeve | ETA-19/0556, ETA-19/0858 | 16/20 | 125/155 | 175/215 | X | X | X | X |
| 5 | HILTI | HSC-A | Zinc plated carbon steel | Undercut | ETA-02/0027 | 8/10 | 46/46.5 | 56/46.5 | X | X | - | X |
| 6 | HILTI | HDA-P | Zinc plated carbon steel | Undercut | ETA-99/0009, ETA-18/0974 | 10/12/16/20 | 107/133/203/266 | N/A | X | X | X | X ¹ |
| 7 | HILTI | HDA-PR | Stainless steel | Undercut | ETA-99/0009 | 10/12/16 | 107/133/203 | N/A | X | X | - | X ¹ |
| 8 | HILTI | HDA-T | Zinc plated carbon steel | Undercut | ETA-99/0009, ETA-18/0974 | 10/12/16/20 | 107/133/203/266 | N/A | X | X | X | X ¹ |
| 9 | HILTI | HDA-TR | Stainless steel | Undercut | ETA-99/0009 | 10/12/16 | 107/133/203 | N/A | X | X | - | X ¹ |
| 10 | HILTI | HIT-Z + HIT-HY 200-A | Zinc plated carbon steel | Bonded | ETA-12/0006 | 12/16/20 | 100/145/145 | 174/238/265 | X | X | - | - |
| 11 | HILTI | HIT-Z + HIT-HY 200-A | Stainless steel | Bonded | ETA-12/0006 | 12/16/20 | 100/145/145 | 174/238/265 | X | X | - | - |
| 12 | WURTH | W-FAZ PRO/S | Galvanized steel | Torque controlled expansion bolt | ETA-20/0229 | 8/10/12/16 | 43/49/60/79 | 98/109/135/174 | X | X | - | X |
| 13 | WURTH | W-FAZ PRO/A4 | Stainless steel | Torque controlled expansion bolt | ETA-20/0229 | 8/10/12/16 | 43/49/60/79 | 98/109/135/174 | X | X | - | X |
| 14 | WURTH | W-HAZ/S | Galvanized steel | Torque controlled expansion sleeve | ETA-02/0031 | 8/10/12/16/20 | 80/95/105/130/160 | N/A | X | X | - | X |
| 15 | WURTH | W-HAZ/A4 | Stainless steel | Torque controlled expansion sleeve | ETA-02/0031 | 8/10/12/16 | 80/95/105/130 | 120/134/155/180 | X | X | - | X |
| 16 | HILTI | HST4-R | Stainless steel | Torque controlled expansion bolt | ETA-21/0878 | 8/10/12/16/20 | 36/38/49/77/116 | 116/128/154/192/215 | X | X | - | X |
| <div><div>Notes:</div><div><ul style="list-style-type: none">• All the products have been selected based on requirement matrix presented in [2].• All the geometrical data is taken from material data sheets of the producers.</div><div>¹ Fire reaction class A1 is available for these PDA products and a conservative fire resistance design method (EN 1992-4 [2]) is available for undercut anchors without REI120 resistances provided in the product specific ETA.</div><div>² The products in the catalogue are compatible with the study performed in [12] and are thus qualified for ITER nuclear safety requirements established in [13]. [the study [12] compatibility parameters are: hdrill<=265mm ; Smin>=100mm ; Do<=40mm]</div></div> | | | | | | | | | | | | |