

CONFORMITY ASSESSMENT MODEL FOR MECHANICAL COUPLING DEVICES AND ANCHORS FOR REINFORCING STEEL FOR USE IN CONCRETE STRUCTURE

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ABSTRACT.

The use of mechanical coupling devices and anchors for reinforcing steel for use in concrete structures can simplify the design and construction of reinforced concrete and reduce the amount of reinforcement required. Technical Approvals of these products by suitably qualified organisations are acceptable under Building Regulations and by major specifiers as the appropriate way of assessing non-standard or new and innovative products. Specifiers, manufacturers, traders, and customers increasingly demand certainty in the quality management of mechanical coupling devices and anchors entering the supply chain. The supply chain is extremely complex. The weak traceability systems and pressure on the supply chain to reduce cost have created the environment where risks increase. This unique and comprehensive model describes the technical and assessment requirements for the conformity of mechanical coupling devices and anchors. It covers all stages in the supply chain from the production, assembly, product performance and evaluation of mechanical properties including tensile strength, ductility, permanent elongation (slip), cyclic loading performance and fatigue performance. The essential elements of the quality management system combined with additional requirements on process control, product testing and robust installation methodology are essential and agreed by all relevant sectors of industry.

KEYWORDS: Certification, mechanical rebar anchors, mechanical rebar couplers, mechanical rebar splicing systems, product conformity.

1. INTRODUCTION

The CARES Technical Approval Scheme for Couplers and Anchors provides a comprehensive assessment process, ensuring complete product traceability to the construction site. A key part of assessment process is the development of a Technical Approval report which not only indicates the performance characteristics and conformity of the product, but also ensures that correct assembly to the rebar is undertaken with robust installation procedures contained within each report.

The CARES Technical Approval Scheme predominantly covers couplers for use with BS 4449 [1] reinforcing steel. CARES with its global presence have recognised the need for more global approvals and have recently introduced a scheme which not only supports CARES approved rebar to BS 4449 [1], but also rebar to EN 10080 [2], ASTM A615/A615M [3], ASTM A706/A706M [3], ISO 6935-2 [4] and SS 560 [5].

The CARES Technical Approval certification scheme for the supply and installation of Couplers and Anchors has been developed in conjunction with the CARES Technical Committee, made up of various interested parties including leading Structural Engineers, specifiers, and coupler producers.

The Schemes are based on the demonstration of

the continuing operation of the quality management system consistent with ISO 9001 [6], the appropriate Quality and Operations Assessment Schedule [7] and the ability to manufacture, supply and / or install material or product complying with BS 8597 [8], Selafeld Engineering Standard [9], Highways England Manual [10] or more recently, ISO 15835 [11].

At the initial approval stage, all quality affecting manufacturing processes are audited whether produced internally or outsourced via approved subcontract suppliers. Once approved, all CARES approved coupler / anchor manufacturers must ensure any design, material specification, supply chain or installation instruction changes are vetted by CARES to ensure any necessary testing is further carried out to ensure product conformity is maintained prior to the change.

The CARES Coupler Technical approval scheme is further supported both downstream and upstream by the CARES Steel Certification scheme where reinforcing bar fabricators must also be CARES approved for installation of couplers on the reinforcing steel (CARES SRC08 Scheme).

2. OBJECTIVE

The objective of the Technical Approval Scheme is to give confidence to the purchaser that the construction

Schedules No.	Description
TA1-A	Technical Approval of Couplers for Reinforcing Steel for use in Structures and Structural elements Designed in accordance with the Fatigue Requirements of Structural Eurocodes
TA1-B	Technical Approval of Couplers for Reinforcing Steel and Reinforcement Anchors for BS 8110 [12] and EN 1992-1-1 [13] Applications for Static Loading in Tension or Tension and Compression.
TA1-C	Technical Approval of Tension Couplers for Reinforcing Steel for Sellafield Engineering Standard [9] Applications
TA1-F	Technical Approval of Couplers for high cycle fatigue and low cycle loading and static loading applications in tension.
SRC08	Quality and Operations Assessment Schedule [7] for the application of mechanical couplers to reinforcing steel

TABLE 1. Quality and Operations Assessment Schedules [7].

product complies with the appropriate specification without the need to undertake separate verification. Additionally, it provides confidence in both traceability and correct installation methodology. This involves the application of quality assurance principles to assess the supplier's and supply chain quality systems and, as appropriate, product testing to ensure conformity with the requirements contained in each Scheme at each part of the supply chain.

3. ASSESSMENT AND CERTIFICATION SYSTEM

3.1. PRINCIPLES

The assessment and certification system employed in the Scheme has been developed around the following common principles:

- The Scheme is concerned with ensuring that the construction product complies with the relevant product Standards and / or client specifications.
- The responsibility for complying with the Standards rests absolutely with the approved Firm.
- The means of providing assurance of consistent compliance with the Standards or Specifications shall be the formal management system for quality, including process control, which the approved Firm is required to have documented and to be operating to the satisfaction of CARES. This system is subject to ongoing audits at periodic intervals.
- A key method of verifying compliance of the product is by the independent assessment and surveillance of the approved Firms management system for quality, including witness testing of the product as appropriate
- Additionally, independent inspection and testing of the product is undertaken by testing laboratories approved by CARES.
- Long Term Quality level reviews and quality complaints are a key feature of the ongoing surveillance programme.

3.2. QUALITY AND OPERATIONS ASSESSMENT (TECHNICAL ASSESSMENT) SCHEDULES

The Schemes Quality and Operations Assessment Schedules [7] for couplers and anchors are shown in Table 1.

3.3. ASSESSMENT

The assessment consists of:

- Full assessment in accordance with the relevant Quality and Operations Assessment Schedule [7].
- The manufacturing process route integrity, including records, resources, training, contract review, product requirements, manufacturing controls and interfaces.
- Review of installation methodology and product dimensional conformance.
- Product conformity assessment by sampling in accordance with the relevant Quality and Operations Assessment Schedule [7].
- Preparation and issue of the CARES Technical Approval Report for the couplers / anchors assessed.

3.4. APPLICANT

The applicant is required to have and be able to demonstrate:

- The ability and resources required to produce the coupler / anchor to the relevant Standard(s) and / or specifications consistently.
- A quality management system which complies with the requirements of ISO 9001 [6], and the relevant Quality and Operations Assessment Schedule [7]. The system shall be described formally in the supplier's Quality Manual.
- Adequate control of approved suppliers and incoming product.
- The ability of the coupler manufacturer to control its supplier is essential in the case of approval of cementitious grouted couplers, where the grout has

tight performance requirements as part of the latest Coupler Technical Approval scheme TA1-F.

- Robust installation methodology which is readily transferrable to downstream fabricators or site installers.

3.5. CERTIFICATION

A recommendation for approval is produced when the manufacturing procedures and product conformity have been assessed and the Scheme criteria have been satisfied and all reported deficiencies have been addressed to the satisfaction of CARES.

A key part of this recommendation process is the preparation and subsequent approval of the coupler / anchor Technical Approval report. Copies of all the issued Technical Approval reports are freely and readily available to download from the CARES website (www.ukcares.com).

The Certificate of Approval is valid for one year with renewal subject to continuing satisfactory performance of the construction product. Firms granted Certificates of Approval are required to reproduce the CARES Logo, and the Certificate of Approval number on all relevant documentation.

3.6. ONGOING SURVEILLANCE

The assessment and certification system employed in the Scheme has been developed around the following common principles:

Firms granted Certificates of Approval are required to undergo surveillance audits by CARES twice per annum, to ensure continued compliance with the required Scheme and Product Standard. Samples of the construction product may be witnessed tested at the manufacturer in addition to the requirement to test "mirror" samples at an independent laboratory approved by CARES.

All Technical approval schemes require that key variables of the original tested component remain unchanged.

The following variables as applicable to the type of approved coupler shall not be changed without the prior agreement and subsequent assessment by CARES:

- a) Coupler component material or grade or process route of the raw material used to manufacture the coupler
- b) Cross-sectional area of the splice sleeve
- c) Bar engagement length
- d) Reinforcing bar profile (rib pattern), grade or specification
- e) Bar locking device
- f) Thread geometry
- g) Torque
- h) Swaging pressure
- i) Die geometry

- j) Production process or production location
- k) Approved grout supplier and / or change in grout specification or properties (in the case of cementitious grouted coupler)
- l) Installation instructions

A key condition of the CARES Technical approval schemes are that any subsequent changes to the above must be reviewed by CARES prior to the implementation of the change, thus ensuring that any extra testing is undertaken to ensure continued product conformity. Failure to do so will usually lead to the removal of the Technical Approval and the CARES approval certificate.

New suppliers deemed critical for the processed part will be assessed by CARES before production can commence. All sub-suppliers are visited at least once every three years as part of the ongoing surveillance

Installation instructions are validated at each surveillance visit, by means of witness sampling of the coupler and application to the reinforcing bar.

3.7. KEY ATTRIBUTES OF THE APPROVED COUPLER / ANCHOR

The approved coupler / anchor attributes include

- a) Tensile properties, ensuring the connected reinforcing steel properties are not compromised
- b) Slip < 0.10 mm (permanent elongation after unloading from 60% / 65% of the characteristic yield strength of the reinforcing steel). This is key requirement in all the CARES Coupler Schemes not only at the initial assessment but also ongoing factory production control surveillances. Control on slip is essential to ensure adequate concrete crack control.
- c) Mode of failure, within or outside the coupler assembly.
- d) Performance in low cycle / high cycle fatigue according to each CARES scheme appropriate to the coupler final application, whether Highway bridges, critical installations such as Nuclear or areas of potential seismic activity.
- e) Designed to allow consistent and robust installation methods readily repeatable whether at fabricators or on site

3.8. METHODOLOGY OF CONFORMITY ASSESSMENT AND ONGOING SURVEILLANCE FOR THE COUPLER / ANCHOR APPROVAL

Key requirements of the CARES assessment and surveillance methodologies are:

- a) Use of assessors who have a background in the Steel production and / or construction industry is critical. These assessors will also have a thorough knowledge of principals of ISO9001, with clear

attention to Factory Production control (FPC), maintenance of traceability, construction product properties and installation methodology.

- b) The manufacturing site visits, including visiting of any key sub-contract operations are agreed with the client in advance and an audit itinerary issued to ensure full understanding of the requirements.
- c) A key part of each audit of the client and any sub-contractors is to establish confidence in their FPC and associated procedures, purchase control and specifications, incoming inspection of goods and final product inspection and release.
- d) Management of change is facilitated using Schedules of operations which are required to be produced by each approved client and required to be updated regularly to detail any changes to the agreed manufacturing process route, critical sub-contractors, purchasing specifications and product drawings. Also included are the issue status of operational procedures for any rebar end preparation / threading machines leased to CARES approved fabricators. These schedules are reviewed during audits to ensure there an adequate management of change record, thus ensuring confidence in the maintenance of the product properties.
- e) Sampling of the assembled product is a key feature at each audit whether at the manufacturer or fabricator following the agreed installation procedure. These are subsequently tested at independent laboratories which are approved by CARES
- f) Continued approval and certification is only allowed following successful auditing and product testing. Any areas for improvement are followed up the issue of non-conformances which require the client to undertake a root cause analysis, immediate remediation, and corrective actions.

4. IDENTIFICATION AND TRACEABILITY SYSTEM

CARES certification provides full traceability from the molten steel to the construction site by addressing all stages of production, delivery, and receipt.

Once installed and cast into concrete within the structure, construction components cannot be easily removed even if there is a product failure or a manufacturing deficiency. There is no 'product recall' when things go wrong with steel in the structure of a prized project. Its performance must be assured from the outset.

CARES have embraced the digitalisation era by developing and promoting its CARES Cloud. This CARES digital platform plans to cover all stages in the supply chain from receipt of raw materials, the manufacture and processing of steel products through to delivery to the end user. It delivers product test

results and sustainability credentials that are traceable across the whole supply chain ensuring that rebar is effectively tested, marketed, and traced. Critically, in the latter stages of this development it could also confirm where these products are installed in the structure.

5. CONSTRUCTION PRODUCT SUPPLY CHAIN - CARES APPROACH

The supply chain is designed to give confidence to the purchasers and the Technical approval schemes are supported by the Steel Schemes as shown in Figure 1.

For a product to be CARES approved, all the supply chain must be approved, whether it is the steel-maker, roller, steel trader or fabricator, there shall be no break in this link.

Coupler installation is rigorously reviewed during surveillance at approved fabricators as part of the CARES Steel Scheme SRC08, ensuring agreed installation procedures are maintained in line with those detailed in the appropriate Technical Approval report. Witnessed coupled rebar is taken for subsequent independent testing at an agreed rate over the surveillance period.

6. ASSESSMENT MODELS AND SPECIFICATION

- **CARES TA1-A**
Quality and Operations Schedule for the Technical Approval of Couplers for Reinforcing Steel for use in Structures and Structural elements Designed in accordance with the Fatigue Requirements of Structural Eurocodes: This scheme is based on the requirements of the Highways England [10] specification for Highways structures, with continual product assessment by independent testing and LTQL. Testing includes both tensile and high cycle fatigue testing.
- **CARES TA1-B**
Quality and Operations Schedule for the Technical Approval of Couplers for Reinforcing Steel and Reinforcement Anchors for Static Loading in Tension or Tension and Compression: This scheme is based on the requirements of BS 8597 [8], with continual product assessment by independent testing and LTQL. Testing includes both tensile and optional compression testing.
- **CARES TA1-C**
Quality and Operations Schedule for the Technical Approval of Tension or Tension-Compression Couplers for Reinforcing Steel and Reinforcement Anchors for Nuclear Applications based on Sellafield Engineering Standard [9]: This scheme is based on the requirements of the Sellafield Engineering Standard

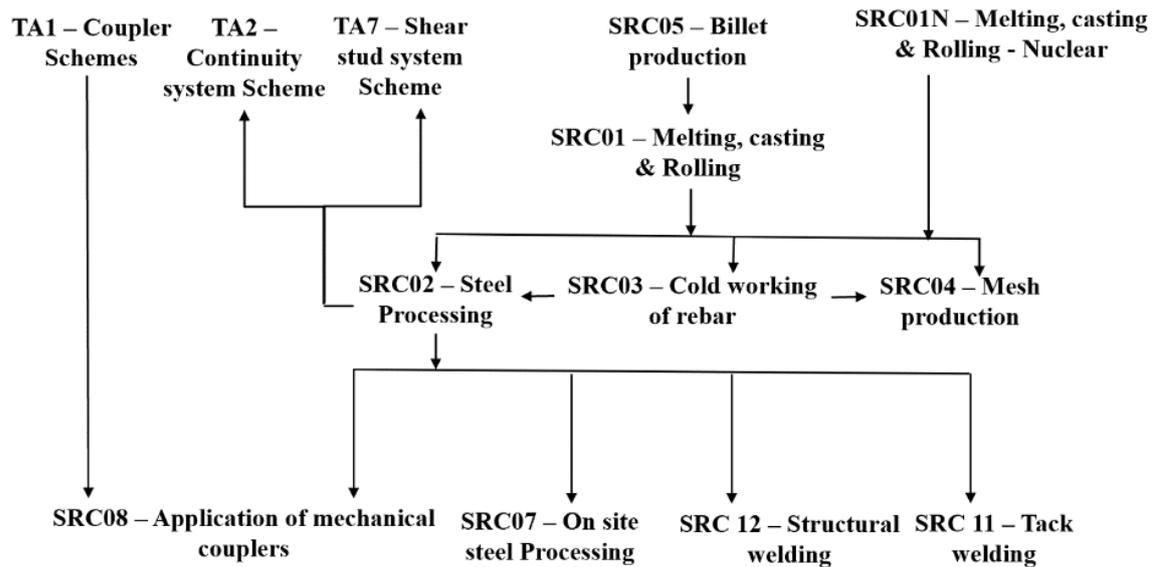


FIGURE 1. Concept of 'extended' product responsibility applied to reinforcing steel.

[9], with continual product assessment by independent testing. Testing includes both tensile, including cold soak tensile testing, low cycle, and high cycle fatigue testing.

• CARES TA1-F

Quality and Operations Schedule for the Technical Approval of Couplers for high cycle fatigue and low cycle loading and static loading applications in tension: This scheme is based on the requirements of ISO 15835 [11] with enhancements. Continual product assessment in line with the standard by independent testing. Testing includes tensile, optional low cycle and high cycle fatigue testing. This is the first CARES scheme to include a cementitious grouted coupler, hence evidence of conformance and product performance of the specified grout is a key part of this scheme. This built on CARES experience of using grout on site for bonded tendons in Post Tensioning installations.

7. CONCLUSION

CARES is an independent, not-for-profit certification body. The certification scheme for both the Steel supply chain and installation of couplers in its requirements, providing for good management control, consistent product and technical conformity, industry developed disciplines, rules and standards and auditing by industry professionals with many years-experiences in the appropriate industry.

CARES reduce the risk of using Construction products which do not meet the Specification requirements, and to enable feedback and corrective action in case problems arise. Major construction clients, designers, and contractors worldwide, recognise and even specify CARES and its certification scheme to

gain assurance of consistent product quality and technical competence.

CARES maintain its Construction products development by attendance at the European Organisation of Technical Approval (EOTA) meetings and actively participate in various ISO, EN and BS standard meetings.

CARES Schemes are prepared in collaboration with the relevant Technical Committees of interested parties which include senior structural engineers, specifiers, and producers.

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