

Model Specification for the Purchase of Structural Tension Assemblies

1. General

- (1) This specification is for the purchase of Group A structural tension assemblies according to BS EN 1993-1-11. The assemblies may be supplied assembled or as separate components. This specification may also be used, as appropriate, for the purchase of the separate components.
- (2) If the product (i.e. component or assembly) is supplied fully in accordance with a product standard or ETA, or the supplier publishes performance characteristics for a proprietary design type, then the supplier takes responsibility for the design of the product and the quality of the manufactured product.

NOTE: BS EN 1993-1-11 and BS EN 1993-1-8 provide the basis for calculating characteristic and design capacities of tension assemblies for use in structural design.

- (3) Otherwise, the purchaser is responsible for the design of the product and the supplier is responsible for the quality of the manufactured product, as follows:
 - (i) The purchaser is responsible for specifying what pre-production testing, including type testing, shall be undertaken;
 - (ii) BS EN 1993-1-11, BS EN 14399-1 and BS EN ISO 898-1 shall be used to determine the pre-production testing that is required (including the suitability of corrosion protection systems);
 - (iii) The supplier is responsible for developing a suitable process route and undertaking all pre-production testing and presenting the results to the purchaser;
 - (iv) The purchaser is responsible for verifying that the test results are acceptable;
 - (v) The component specifications shall then be agreed between the purchaser and the supplier (see 4(1));
 - (vi) The manufacturer is responsible for implementing suitable factory production control to ensure that the process route used for manufacture of the pre-production prototypes is followed during manufacture (whether the components are manufactured in-house or by sub-suppliers) and for verifying that the components conform to the component specifications.

NOTE: This procedure is in accordance with BS EN 14399-1 where the product design is not undertaken by the manufacturer. BS EN 14399-1 is based on the use of initial type testing and factory production control for the evaluation of product conformity.

- (4) The supplier's responsibility includes ensuring that the components comply with the EU's Construction Products Regulation (CPR), whether the components and/or the constituent products or materials are manufactured within the EU or imported from outside the EU.

NOTE: The term "constituent products" refers to the steel products and materials used to manufacture the components of the tension assemblies.

2. Scope

- (1) Ordinary tie bar assemblies are outside the scope of this specification.

NOTE: Ordinary tie bar assemblies are threaded bars up to M36 supplied with nuts and, if required, washers suitable for non-preloaded applications and are within the scope of the BCSA's *Model Specification for the Purchase of Structural Bolting Assemblies and Holding Down Bolts*.

- (2) Structural tension assemblies consist of steel tie bars and steel connectors.

NOTE: This specification does not cover Group B or Group C tension assemblies to BS EN 1933-1-11 that use stranded cables or wire ropes.

- (3) BS EN 14399-1 shall apply to tie bars as extended-length studs.

NOTE: Requirements in BS EN 14399-1 related to bolt heads are not relevant. BS EN 14399-1 defines the number of samples to be tested and conformity criteria for initial type testing and product testing.

- (4) Connectors may be manufactured from cast, forged or rolled steel constituent products or materials. Connectors may be manufactured by machining, drilling and/or threading.

NOTE 1: This specification does not cover lug plates etc used to secure the ends of tension assemblies that are welded to other structural components. This specification does not cover the use of welding to manufacture connectors or to join tie bars. For welding and other general execution requirements, purchasers and suppliers are referred to BS EN 1090-2.

NOTE 2: Typical connector components include:

- spade and forked ends (often termed clevis or yoke connectors),
- couplers and turnbuckles (with left and/or right hand threads),
- swivel connectors (hinged or universal/cardan style),
- tongue and cheek plates,
- lock covers, pins, clevis pins, end caps, screws, nuts and locknuts.

NOTE 3: Guidance on specification of castings for use in construction is given in steel industry guidance note SN24.

- (5) Assemblies may include components such as nuts, washers and retaining screws supplied to European or International Standards.

NOTE: If the relevant European Standard is harmonised under the CPR, see 4(4) below.

3. Component specifications

- (1) The agreement between the purchaser and supplier shall be based on a schedule itemising the following:

- (i) The list of components to be supplied.
- (ii) Overall nominal dimensions of the tension assemblies as manufactured.
- (iii) The supply condition (assembled or as separate components), and if separate whether trial assembly of a representative sample is required (see 6(12)).
- (iv) The surface coatings to be applied for corrosion protection and/or surface protection of internal and/or external threads and machined bearing surfaces.
- (v) The test temperature applicable to impact testing (see 6(7)).
- (vi) Whether more than 10% NDT is required for cast steel components and/or alternative acceptance criteria (see 6(10) and 6(11));
- (vii) Whether proof testing is required and, if so, the nominal capacity to be used and a value for K if not 0.85 (see 3(2), 6(14) and 6(15)).
- (viii) Whether ultimate breaking capacity testing is required (see 6(16)).
- (ix) Action to be taken to rectify non-conformities (see 7(1)).
- (x) Whether the assemblies and components are to be fatigue resistant, and (if so) the additional specific requirements.

NOTE: BS EN 1993-1-11 provides guidance on tests including fatigue tests. (Cross references to EN 10138 may be ignored as that standard has not been published).

- (2) Unless otherwise agreed with the purchaser, the load bearing capacity of the assembly shall not be less than the nominal capacity of the tie bar alone based on its nominal yield or 0.2% proof strength times the minimum nominal cross-sectional area.

NOTE 1: For threaded tie bars designed for full loadability according to BS EN ISO 898-1, the minimum cross-sectional area will be across the thread root.

NOTE2: Some steel product standards for constituent products use a reference strain of 0.1% for proof strength.

4. Quality management

- (1) The supplier shall develop component specifications for all components of the tension assembly, and an assembly drawing of each tension assembly type.
- (2) For batches of nominally identical components, lot control shall be used during manufacture. Inspection lots shall be the same as manufacturing lots. A lot is a maximum of 50 nominally identical components produced from constituent products or materials from the same cast/melt and the same heat during subsequent heat treatment.

NOTE: BS EN 14399-1 defines manufacturing and assembly lots and may be used as a reference to assist manufacturers to implement appropriate lot control.

- (3) All components of finished assemblies shall be traceable (on a lot basis or uniquely as appropriate) to their respective cast/melt and/or heat treatment records as appropriate.
- (4) If constituent products or components are within the scope of a harmonised European Standard or European Technical Approval (ETA), only CE Marked products shall be used.
- (5) Constituent products shall be subjected to specific inspection and supplied with Type 3.1 (or 3.2) inspection certificates to BS EN 10204.
- (6) Fabricated components supplied to the purchaser according to BS EN 1090-2 as part of the tension assembly or used in manufacture shall be to EXC2 as a minimum.
- (7) The supplier shall identify a person with suitable technical knowledge and experience to coordinate the supply of the tension assembly components, including:
 - (i) Review of purchaser's requirements
 - (ii) Submission of the results of pre-production testing to the purchaser if the purchaser is responsible for the design of the product;
 - (iii) Submission and agreement of the component specifications with the purchaser;
 - (iv) Identification of the process routes for the production and surface treatment of all components;
 - (v) Ensuring that all processes that affect the metallurgical microstructure are reviewed by a competent metallurgist;
 - (vi) Development and implementation of the inspection and test plan, and, if requested by the purchaser, submission of the inspection and test plan to the purchaser (see 6(1));
 - (vii) Review of the qualifications of laboratories and personnel used for testing;
 - (viii) Review and recorded acceptance of inspection certificates and/or certificates of conformity from sub-suppliers;
 - (ix) If requested by the purchaser, agreement of requirements for hold-points or witness inspections or tests, and coordination of these (see 6(2));
 - (x) Reports of actions taken to resolve non-conformances (see 7(1) below);
 - (xi) If requested by the purchaser, submission of quality documentation package to the purchaser (see 8(4) below).
- (8) All suppliers and sub-suppliers of manufacturing components, constituent products or materials that are not covered by either a harmonised European Standard or an ETA shall have a quality management system certified to BS EN ISO 9001 by a certification body accredited by UKAS (or equivalent).
- (9) The supplier shall inform the purchaser of the country of origin of all components, constituent products or materials from outside the EU. The supplier shall allow the purchaser the right to perform a pre-production quality audit at the premises of the supplier and/or sub-suppliers.
- (10) For each sub-supplier from outside the EU, in addition to the sub-supplier's inspection and testing, the supplier shall implement an acceptance inspection regime for mechanical properties modelled on BS EN ISO 3269 at the point of entry into the EU, unless the supplier has evidence of satisfactory compliance from that sub-supplier over a period of more than one year.

NOTE: BS EN ISO 3269 is based on a limiting quality (LQ) in the sampling plan that corresponds to a probability of less than or equal to 10% (LQ₁₀). For especially critical components it may be necessary to specify LQ₀.

5. Technical requirements

- (1) The deviation of a tie bar length from the specified overall length shall be in accordance with Table 5.1.

TABLE 5.1 PERMITTED DEVIATIONS FOR LENGTH OF TIE BARS

Finished length (L) of tie bar (mm)	Permitted deviation
≤5000	±L/1000
>5000 and ≤10000	±10mm
>10000	±15mm

- (2) The out-of-straightness of a tie bar shall be in accordance with Table 5.2.

TABLE 5.2 PERMITTED DEVIATIONS FOR OUT-OF-STRAIGHTNESS OF TIE BARS

Diameter of tie bar (mm)	Permitted deviation
≤80	L/250 over whole length (L)
>80	L/400 over whole length (L)
All diameters	1mm over 1m gauge length

NOTE 1: These requirements are generally in accordance with BS EN 10060 and BS EN 10278 for the manufacture of steel bars.

NOTE 2: A bar may be considered as being inelastically kinked if it exhibits a permanent out-of-straightness of more than 1mm over a 300mm gauge length.

- (3) The deviation from specification of an internal or external threaded length excluding thread run-out shall be -0/+10mm.
- (4) The threads of threaded components shall be in accordance with tolerance class 7H/6g to BS ISO 965-3.
- (5) The diameter of pins shall be in accordance with tolerance class 8g to BS EN ISO 286-2.
- (6) The dimension of holes for pins shall be in accordance with tolerance class H11 to BS EN ISO 286-2.
- (7) The roughness of machined surfaces shall be in accordance with Ra 12.5 to BS EN ISO 1302.
- (8) The surfaces of the tie bars shall be smooth with no visible defects such as seam, lap, delamination, scab or corrosion.
- (9) The deviation of the length of complete tension assemblies from the specified overall length shall be in accordance with Table 5.3. If assemblies contain threaded components that are adjustable compliance with Table 5.3 shall be achieved without the loss of thread engagement of more than 5mm from the nominal mean at any threaded connection position.

TABLE 5.3 PERMITTED DEVIATIONS FOR LENGTH OF TENSION ASSEMBLIES

Overall length of assembly (mm)	Permitted deviation (mm)
≤5000	±5
>5000	±10

- (10) The deviation from the intended alignment between a connector and a tie bar after assembly shall not exceed 1 in 150.
- (11) Nominally identical components supplied as part of a single assembly lot shall be interchangeable during assembly.

6. Inspection and testing

- (1) The supplier shall prepare a comprehensive inspection and test plan (ITP) for production and delivery of all components. If requested, the supplier shall submit this to the purchaser for review prior to the commencement of manufacture. The review of the ITP by the purchaser does not relieve the supplier of the responsibility for supplying components that conform to the component specifications.

NOTE: Annex 1 provides guidance on the content of an ITP.

- (2) If requested, the supplier shall allow the purchaser the right to appoint an inspection authority to witness testing.

NOTE 1: In addition to production testing (including final acceptance tests), this also applies to pre-production tests (including type tests) if the purchaser is responsible for the design of the product.

NOTE 2: Annex 1 provides guidance on witnessing testing.

- (3) The supplier is responsible for ensuring that the ITP supports the supplier's declaration that the tension assembly and its components comply with the component specifications.
- (4) The ITP shall be formulated to deal with the following situations in terms of pre-production testing and production testing:
- (i) Components to standard generic types or families for which initial type testing already exists and production testing is based on ongoing sampling;
 - (ii) Components of a bespoke type or family for which additional type testing is needed and production testing is specific to this manufacturing lot; or
 - (iii) Unique components for which type testing and production testing are undertaken in the same set of tests.

NOTE 1: BS EN 14399-1 provides guidance on how fastener components may be grouped into families. For instance, tie bars of the same diameter but with differing lengths may be considered as one family.

NOTE 2: In case (iii) type testing is still considered part of pre-production testing although it takes place concurrently with production testing.

- (5) The properties of constituent products and materials may be established by reference to inspection certificates.
- (6) The mechanical properties and chemical composition of cast or forged steel components shall be established by destructive testing of:
- (i) Prototypes, and
 - (ii) Samples (one from each manufacturing lot), or
 - (iii) Loose or attached test blocks of comparable and proportionate cross-section cast/forged and heat treated as appropriate at the same time as the production casting/forging, or
 - (iv) Coupons of a proportionate cross-section cut from the elongated production casting/forging.

NOTE: The term "cast steel components" refers to steel products manufactured to BS EN 10340 and does not include steel products manufactured to BS EN 10025 or similar product standards.

- (7) For cast steel components the ITP shall include the following destructive tests on items taken at random from production:

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- (i) Tensile and elongation tests (one unit per melt);
 - (ii) Impact tests (three units per melt);
 - (iii) Reduction of area test (one unit per melt if appropriate).
 - (iv) Chemical analysis (one unit per melt); and
 - (v) Microscopic examination of cross-sections (one unit per melt).
- (8) If the metallurgical microstructure of cast, forged or rolled constituent products is affected by subsequent manufacturing processes, tests shall be used to establish the results of changes to the properties listed in 6(7).
- (9) Tests and test methods shall be in accordance with the appropriate standard for steel products.

NOTE: See BS EN 10025-1 and BS EN 10340.

- (10) For cast steel components the ITP shall include 100% visual inspection (VT) and the following supplemental non-destructive tests (NDT) unless otherwise agreed with the purchaser:
- (i) MT or PT of surface-breaking discontinuities on 10% of each manufacturing lot; and
 - (ii) UT or RT to detect sub-surface discontinuities on 10% of each manufacturing lot;

NOTE: For especially critical components it may be necessary to specify 100% NDT. If full volumetric coverage is required, RT may be necessary (see BS EN 12681).

- (11) Unless otherwise agreed with the purchaser, acceptance criteria for cast steel components are:
- (i) SM2 and LM3/AM3 to BS EN 1369 for MT;
 - (ii) Severity level 2 to BS EN 12680-1 for UT.

NOTE: ASTM E186-10 may be used as an alternative for assessing the quality of cast steel components. If RT is performed, severity level 3 is recommended.

- (12) The ITP shall include dimensional checks on dimensions and thread fits for each manufacturing or assembly lot of components and/or assemblies as appropriate. If components are being supplied separately, the purchaser may request trial assembly of a representative sample of components.

- (13) The ITP shall include inspection and testing to verify that applied surface coatings are in accordance with the relevant specification and/or coating manufacturer's data sheet.

- (14) If agreed with the purchaser the ITP shall include proof testing of tension assemblies.

NOTE 1: Generally it is advisable to undertake at least one proof test for every assembly lot unless the load bearing capacity of components and assemblies has been previously established by initial type testing.

NOTE 2: In some cases it may only be practicable to undertake proof testing on sub-assemblies of components. In such cases, enough tests on sub-assemblies should be undertaken to prove the performance of the whole tension assembly.

NOTE 3: If the components and/or assemblies are too large for proof testing, then the capacity of may be based on the results of destructive tensile tests and associated finite element simulations of component behaviour.

- (15) If proof testing is undertaken, the following procedure shall be followed:
- (i) Establish the nominal tensile load bearing capacity of the assembly (see 3(2) above).
 - (ii) Assemble the components and mount the assembly on the testing machine, and apply a tensile load until it reaches 10% of the nominal capacity.
 - (iii) Check if all components are working properly and measure the length of the assembly (L_0).
 - (iv) Gradually increase the test load until it reaches K times nominal capacity and hold this load for 10 minutes and then decrease it to 10% of the nominal capacity.
 - (v) Use a value of $K = 0.85$ unless otherwise agreed with the purchaser.

- (vi) Measure the length of the assembly (L_1) and calculate the residual permanent set (s) using the following formula: $s = 100\% \times (L_1 - L_0) / L_0$.
- (vii) Release the test load and visually check all components.

NOTE: The value of s is useful for establishing how the tension assembly will behave under load.

(16) If agreed with the purchaser the proof testing shall be continued to establish the ultimate breaking capacity of the tension assembly, or individual components.

7. Non-conformance reports

- (1) If the dimension or appearance of a component does not conform to the agreed requirements, the supplier may rectify the defect and then perform re-inspection and/or re-testing after the defects are removed unless this is prohibited by the purchaser.
- (2) The supplier shall inform the purchaser of the location of repairs to the surface of steel castings undertaken by welding.

NOTE: See BS EN ISO 11970.

- (3) If a non-conformity is discovered after delivery, the supplier shall replace the product or rectify the problem immediately and make available to the purchaser the results of the corrective action taken.

8. Delivery

- (1) Unless the purchaser is responsible for the design of the product, the supplier shall provide to the purchaser a declaration of performance for the finished tension assembly. Otherwise, the supplier shall provide to the purchaser a declaration of conformity that the tension assembly components conform to the requirements of this specification (see 4(1)).

NOTE: In the latter case this includes a declaration that the individual finished components identified by lot numbers comply with the relevant component specifications.

- (2) The supplier shall report the value of the residual permanent set (s) if proof testing of the tension assembly is performed (see 6(15) above) or ultimate failure load if measured (see 6(16) above).
- (3) If requested by the purchaser, the supplier shall provide to the purchaser a record of the production tests performed in accordance with the ITP together with inspection certificates for constituent products identified by lot numbers or traceable to identified components as appropriate.
- (4) The supplier shall package the assembly or components in a suitable way to prevent damage or corrosion during careful handling and transport, and shall provide the purchaser with instructions for careful handling and transport.

NOTE: This should include specific precautions to avoid damage to external threads and to avoid kinking of tie bars by bending during lifting for which a maximum permissible stress due to lifting of yield/2 is recommended.

ANNEX 1: Guidance on an Inspection and Test Plan and Witnessing Testing

This Annex provides guidance on the content of an inspection and test plan (ITP) and on witnessing testing. If there are specific inspection and/or testing provisions given in this model specification or a relevant BS, BS EN or BS EN ISO standard then those provisions should supersede items in this Annex, as appropriate.

This guidance is based on requirements given in European Technical Assessments for structural tension assemblies manufactured in batches for use in pre-tensioning and post-tensioning applications.

Item	ITP Frequency of Sampling by the Supplier	Frequency of Witnessing Based on 1 visit before deliveries from the supplier are commenced, and thereafter 1 visit for every 1000 sets of assemblies or every six months (whichever is the more frequent)
Review of properties of constituent products and materials declared in documentation issued by manufacturers of origin	100%	Review of 2 sets per visit taken at random from documents for batches of incoming delivered products/materials from every sub-supplier
Testing of metallurgical properties (e.g. surface hardness)	1 in 200 Minimum 2 off	Witnessing of 2 sets per visit of metallurgical tests undertaken by the supplier
Detailed dimensional checking of components including gauge testing of threads etc	1 in 20 Minimum 2 off	Witnessing of 1 complete set of dimensional checks undertaken by the supplier
Overall dimensional checking of assemblies	1 from first 5 complete sets of components produced 1 from every 200 complete sets thereafter	Review of the supplier's records of all overall dimensional checking undertaken (since previous visit)
Overall mechanical performance testing of assemblies or components	1 from first 5 complete sets of components produced 1 from every 200 complete sets thereafter	Review of the supplier's records of all overall mechanical performance testing undertaken on assemblies (since previous visit) <i>Alternatively, if mechanical testing has been undertaken on single components not assemblies:-</i> Witnessing of the single component testing undertaken on a series of 3 components together with review of the supplier's records of mechanical performance testing undertaken (since previous visit)
Visual inspection of surface condition (before application of coatings) for smoothness, absence of laps	100%	Visual inspection of 5 samples per visit
Visual inspection of coatings (applied for corrosion protection etc)	100%	Visual inspection of 5 samples per visit
Checking of marking and labelling	100%	Visual inspection of 5 samples per visit