

DRAWING AND DETAILING OF LATTICE STEEL TOWERS

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PURPOSE AND SCOPE

This document forms part of a suite of documents which define National Grid's functional and performance requirements for new plant and equipment.

This Specification covers the requirements applicable to drawings for lattice steel towers and tower steelwork and shall include new designs, metrication, CDM modifications and other modifications to existing drawings.

PART 1 – PROCEDURAL

1 QUALITY ASSURANCE

The Contractor's Quality Assurance arrangements shall conform to the relevant requirements of BS EN ISO 9000 series.

The programme of work shall contain hold points where the Engineer's comments or inspections are necessary before the work continues to the next phase. (The Engineer shall be a person appointed by NG to act on their behalf). Hold points shall coincide with the following:

- a) Submission of the wire clearance diagrams;
- b) Submission of the GAs and Eds;
- c) Submission of foundation steelwork drawings;
- d) Steelwork check erection.

Prior to submitting drawings to the Engineer for review and comments/acceptance, they shall be independently checked and approved. The checker shall be a person qualified to carry out this type of work but who was not involved in producing the drawings being submitted. The checker shall sign the "Checked/Date" box on each drawing to certify that the check has been carried out. The approver shall not be the same person who carried out the checking.

The Engineer or their representative will review the drawings. Any comments that they may have shall be made in writing.

All subsequent modifications to drawings shall be similarly checked, and reviewed.

Any drawing modified from a previous issue shall bear a new revision number and the nature of the modification shall be clearly stated in the issue box. Original non-CAD drawings shall not be modified unless the nature of the modification is minor i.e. text changes. For non-minor modifications a new CAD drawing shall be produced to show the desired modification. In this case the new drawing shall retain the original number with an incremental revision and the original drawing to be noted as being superseded.

A maximum of three weeks from receipt of drawings shall be allowed for the Engineer's approval or comments provided that the quantity of drawings in any submission is not excessive.

The prime responsibility for the contents of drawings carried out under this Specification rests with the Contractor. The waiver, verification or acceptance of any drawing by the Engineer shall not release the Contractor from any of his obligations under the Contract.

2 DRAWING REQUIREMENTS

Drawings shall be prepared at appropriate scales for ease of reading and shall be sized at A0, A1, A2, A3 or A4 size as necessary. They shall be prepared using a CAD system and the electronic format supplied shall be ".dwg" unless otherwise agreed with the Engineer.

All drawings shall incorporate a standard National Grid title block and frame. The titling convention shall be in accordance with TP135.

Unless specifically stated otherwise, the copyright of drawings shall be invested in National Grid. By accepting a Contract, which includes the production of tower drawings, the Contractor agrees that the copyright of those drawings will be owned by National Grid. Each drawing shall bear the legend "Copyright - Not to be reproduced without the written permission of National Grid".

The Contractor shall not divulge any aspect of the design and/or detailing to any third party not directly involved in the drawing work/supply of the tower steelwork.

The type of drawings required on any one Contract and covered by this specification may be any, or all, of the following:

- a) Wire clearance drawings (WCD's);
- b) Key diagram and drawing reference;
- c) General arrangement drawings (GA's);
- d) Erection drawings (ED's);
- e) Foundation steelwork and stub setting details;
- f) Piece small details (PSD's) of all components for fabrication;
- g) Material lists including weights of all components;
- h) Bolt lists including weights of bolts, nuts, washers and locking devices;

Unless otherwise agreed, dimensions on all drawings shall be in metric units (mm).

2.1 Wire Clearance Drawings

Before commencing tower steelwork drawings, generic wire clearance drawings (WCDs) shall be produced to prove the clearances specified for the tower. A generic WCD shall comprise a drawing showing the arrangement of the tower, insulators, conductors and jumpers together with minimum specified live metal to earthed metal clearances in still air and under swing conditions. Clearances and insulator/ jumper swing conditions are specified in TS 2.4. For modifications to existing towers, the Engineer will advise the original design swing conditions and clearances applicable to their design if those in TS 2.4 are not applicable.

The full requirements for the production of WCDs shall include the proving of clearances under the following conditions:

- a) For suspension towers – with insulators in still air and under specified swing conditions;
- b) For angle/tension towers – with specified maximum and minimum angles of line deviation and with maximum and minimum insulator set lengths together with jumper loops in still air and under swing conditions;
- c) For terminal towers and tension towers with downleads to sealing end platforms – the above together with specified minimum clearances between phase conductors;

For determining the clearance from live conductors to tower steelwork the following shall be assumed:

- a) Suspension towers – The conductor may leave the suspension clamp at any angle up to 20 degrees below the horizontal;
- b) Tension towers – The main conductors and insulators may leave the crossarm at any angle up to 20 degrees below the horizontal or 10 degrees above the horizontal (representing the uplift condition).

2.2 General Arrangement Drawings

Towers shall be detailed so as to allow assembly and erection in the field. Generally, towers shall be fabricated from steel angle section members connected together with bolts, nuts and washers. However, other steel sections may be used where it is more appropriate to do so. Where necessary, for practical reasons, shop-welded components may be employed. Site welding is not permitted in any circumstances.

Structural members and other components shall be hot-dip galvanised, hot-rolled sections conforming to the requirements of TS 3.4.16.

Bolts, nuts, washers and locknuts shall be hot-dip and spun galvanised and shall conform to the requirements of TS 3.4.16.

General Arrangement (GA) drawings shall show all principal tower dimensions, section sizes and material grades. Section size and material grade shall be shown for each member. This may be in the form of a general note or shall be shown adjacent to each member where clarity of the drawing is not impaired. The grade of steel to be stated thus: MS (for mild steel) or HTS (for high tensile steel).

The use of gusset plates shall be avoided wherever possible, unless detrimental to the design, by adjustment to the setting out of connections and/or the use of staggered back marks.

A key diagram, or location plan, shall be included on each GA drawing indicating which part of the tower is referred to on the drawing. This shall, wherever possible, be adjacent to the title block. Adequate cross-referencing of drawing numbers between tower panels shall be provided.

2.3 Erection Diagram Drawings

Erection Diagram (ED) drawings shall show bar mark numbers and the number, diameter and length of bolts in each connection. The mark number shall be shown above each member where clarity of the drawing is not impaired. Bolt details shall be placed as closely as possible to bolts and bolt groups.

Note: Combined GA & ED drawings are acceptable and are preferred.

Each bar or plate shall be clearly identified by a mark number. Where two or more members are identical, they shall be allocated the same number. Where two bars differ only by virtue of their being handed, they should each be allocated the same mark number, but suffixed R or L (R denoting that the member occurs on the right-hand side of the tower). The suffix M is to be used for metricated members on Imperial structures.

For the purposes of safety, horizontal plan members connected by bolts in the vertical plane shall be fitted with nuts to the top side. This shall be noted on the erection drawing.

All mark numbers on each tower design or portion of tower shall carry the same prefix which will normally be allocated by the Engineer. Mark numbers shall be allocated in a logical sequence. Each ED (or GA & ED) drawing should indicate the range of mark numbers depicted upon it. A suitable number of spare mark numbers are to be allocated to each drawing for use in the event of future revisions. A table shall be included, adjacent to the title block, showing the range of numbers used and the spare numbers.

A key diagram, or location plan, shall be included on each ED indicating which part of the tower is referred to on the drawing. This should be adjacent to the title block. Adequate cross-referencing of drawing numbers between tower panels shall be provided.

2.4 Component Detail Drawings

Component detail drawings shall be produced for fabrication purposes. All detail drawings shall have both string dimensions and running dimensions. Bar details shall be drawn to third angle projection on either A4 or A3 sheets. Drawings need not be to scale, but should be drawn such that holes relate to one another in the correct order. Typical piece small detail drawing format is shown in Appendix D.

Bar detail drawings should be noted as STAMP THIS END at the top end of all vertical or inclined bars and STAMP EITHER END on all horizontal bars in order to indicate the preferred location for the stamped bar mark.

In order to avoid fabrication difficulties, no bar should be bent to an angle of less than 1 in 50 and skew bends should be avoided as far as possible.

Pockets and depressions likely to hold water shall be avoided where possible, but if unavoidable, they shall be properly drained e.g. by providing drain holes.

Where stitch bolts are required to connect together the individual members of composite bracings, packs or pack washers shall be used. They shall also be used at the intersection of single diagonal bars in cross bracings. The thickness of packs and pack washers shall be commensurate with the spacing of the members at their end connections.

For ease of personnel accessing the tower, horizontal members shall be detailed toe down wherever possible.

Bending of members shall be subject to the requirements of TS 3.4.16. Plated joints shall not be permitted in order to achieve such bends.

2.5 Connections

Crossarms shall be so detailed that they can be disconnected without disturbing any member forming part of the tower body.

At all conductor or earthwire attachment locations where vibration is likely to occur, bolts fitted in plates or ends of members shall have two nuts fitted. Pal nuts shall not be acceptable.

Butt joints shall normally be made with inside and outside cover plates rather than bosom angles and cover plates.

The minimum diameter of structural bolts shall be 16 mm. Flat washers shall be provided immediately under nuts. These shall be of 4 mm thickness with an external diameter of nominal bolt diameter + 15 mm and a hole diameter of nominal bolt diameter + 2 mm. "Palnut" locking devices shall be provided for all structural bolts.

Bolt lengths shall be determined from the following:

- a) No part of the threaded portion of the bolt shall be within the shearing plane between members;
- b) The length of thread within the bearing area shall be less than 1mm;
- c) When three or more items, including pack washers, are connected then 1 mm shall be added to the combined thickness. See bolt grip table in Appendix C;

- d) After fitting with nut(s) and locking device the bolt shall project a minimum of two clear threads from the locking device. Pack washers, where required, shall have an external diameter of twice nominal bolt diameter + 15 mm and a hole diameter of nominal bolt diameter + 2 mm.

Hole diameters in members and other components shall be in accordance with TS 3.4.16. Minimum dimensions for hole centres and for edge distances from hole centres shall be as Table 1 below.

Bolt Diameter (mm)	Hole Centres (mm)	End Distance (mm)	Distance to rolled edge (mm)	Distance to sheared edge (mm)
16	40	24	20	24
20	50	30	25	30
22	54	33	28	33
24	60	36	30	36
30	75	45	38	45

Table 1 - Minimum dimensions for Hole Centres, End and Edge Distances

2.6 Material Lists and Bolt Lists

Material lists shall schedule the total number of components called for in the design including their mark numbers, member designation and size, quantities, length, width (plates and flats), steel grade and weights.

The material list and bolt list shall reference the drawing number for the Erection Diagram (GA/ED).

Material weights shall be calculated to one decimal place of a kilogram. Bolt weights shall be calculated to two decimal places of a kilogram. Where two or more pieces are welded together to form one unit, they should be grouped together on the schedule and only the complete weight indicated. Weight calculations shall be based on the gross section for structural members and based on the length x width for plates and flats.

Material lists shall include fittings necessary for the connection of insulators and earthwires to the tower. These shall generally comprise swivels complete with retaining bolts or pins.

Bolt lists shall include quantities and weights for each diameter, steel grade and length of bolt, and for round washers, pack washers, tapered washers, palnuts and step bolts. Five per cent spares of each item shall be included in the list.

Material and bolt lists shall be provided for each panel or portion of the tower. These shall also record the total weights of material and bolts in each panel or portion.

2.7 Foundation Steelwork Drawings

The Contractor will be provided with sufficient information to allow him to produce stub setting drawings and foundation steelwork detail drawings.

Stub setting drawings shall clearly indicate all dimensions necessary for setting out the excavations, and for the accurate placement of the tower stubs within the foundation, for all tower heights. Stub lengths and stub setting shall allow for the construction of foundations without the need for separate muffs on sites where ground levels vary by no more than 300 mm between tower legs.

These requirements are detailed in TS 3.4.15.

Foundation stub detail drawings shall be produced for the tower. They will include the main leg stubs and the number and size of cleats required together with connection details. The top portion of the stub (top of concrete to top of steel) to be drilled with adequate holes to suit all leg extensions raker members while complying with the requirements of section 2.5.

2.8 Check Erection

The first whole, or part tower, built to a new design shall be check erected. Therefore, the first issue of all general arrangement and erection drawings shall carry a clear note that the tower is to be proven by check erection. Following successful check erection, and the incorporation on all drawings of any changes found necessary, the initial note will be removed and the drawings reissued as a revision with a note indicating that the detailing has been proven by check erection.

3 TOWER FEATURES

The following features shall be incorporated into all tower steelwork drawings.

3.1 Cattle Guards

In order to avoid risks of entrapment of livestock, cattle guards shall be detailed and fitted to tower bases as shown in Appendix A, Fig 1. These shall be fabricated from 5 mm thick mild steel and shall be included in the material and bolt lists for each tower height.

3.2 Access Facilities

Climbing facilities shall be provided on each tower, and each tower extension from ground level to the top of the tower peak. Generally, these shall comprise the fitting of step bolts to tower legs.

Where a crossarm intersects with a tower leg, and the normal placement of step bolts is impracticable, another solution shall be adopted. Tower members, as fitted, may themselves provide a convenient climbing aid. Where cruciform plates are used to connect main and auxiliary crossarms to the tower body special step plates are likely to be required.

All four legs of towers shall be drilled for step bolts from the ground to the earthwire peak at not less than 330 mm, and not more than 380 mm, centres. Step bolts shall be spaced as evenly as possible and the variation between adjacent pitches should not exceed 10 mm.

Generally, step bolts shall be 16 mm diameter mild steel fitted with a washer under the fixing nut. If the only practicable location for a step bolt means that it must be combined with a structural bolt then this will be acceptable provided that the structural bolt diameter is 20 mm or greater. As all structural bolts are high yield steel, this will prevent the wrong step bolt being used.

Step bolts shall be scheduled for the tower as follows:

Step bolts of 16 mm diameter mild steel -	for two legs only from the anti-climbing device (ACD) to the top of the earthwire peak.
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Structural step bolts of greater diameter - for all four legs from ACD to peak. The lowest position at which the anti-climbing device may be fitted is 2.5m above ground.

Details of step bolts are given in Appendix A, Figure 2.

Note. Where drawings exist for main and other step bolts these should be marked with a note stating that they are now superseded by this specification.

At a location approximately 1.25 m below the fixing of circuit identification plates, step bolts shall be provided in each flange of the leg to provide a standing position.

3.3 Anti-climbing Device, Plates and Signs

Anti-climbing devices generally do not require any special provisions for attachment as these are clamped to the tower. Anti-climbing devices are specified in TS 3.4.27.

The requirements for plates and signs are given in TS 3.4.9. Plates and signs are clamped to the tower body with the exception of property plates, tower number plates, phase plates and circuit identification plates with support steelwork and/or drillings need to be included in the tower drawings. Support steelwork and drillings shall be detailed for each tower height.

3.4 Provision for Tower Earthing

In order to enable earth electrodes to be bolted to the tower, each main leg shall be provided with two 17.5 mm diameter holes placed 50 mm apart at a position approximately 0.6 m from ground level.

3.5 Provision for Earth Bonding

Two 17.5 mm diameter holes, one either side, shall be provided in the peaks of towers to facilitate the attachment of earthwires to the towers by flexible earth bonds.

4 FACILITIES FOR STRINGING

4.1 Alternative Locations for the Attachment of Earthwires

Wherever practicable, alternative holes shall be provided for earthwire attachment on either side of the main attachment point and at a distance of 125 mm from it. For new tower designs the earthwire attachment at the tower shall be via swivels. Earthwire swivels may be retained by bolts.

4.2 Locations for the Attachment of Stringing Equipment

For new tower designs the standard arrangement for insulator attachment and maintenance holes at tension tower crossarm ends shall be as shown in Appendix A Figures 3A and 3B. Phase conductor/insulator attachment at the tower shall be via swivels. Tension swivels shall be retained by pins, threaded each end, as shown in Figure 3B. This arrangement is required to suit the connection of maintenance equipment.

In order to assist with lowering or raising suspension insulators, attachment swivels shall incorporate an extra lug at the top of the swivel containing a lifting hole. The crossarm end shall be detailed to allow the insulator complete with swivel to be lifted into place before securing with the swivel retaining bolt.

4.3 Seahorse Lifting Derrick

Near the ends of top crossarms on all towers, provision shall be made for the fitting of Seahorse derricks for lifting smaller items of equipment. Where practical this shall comprise