MANUAL

TELECOMMUNICATIONS TOWERS AND GUYED MASTS

DEP 32.71.00.14-Gen.

July 1996

DESIGN AND ENGINEERING PRACTICE

PREFACE

DEP (Design and Engineering Practice) publications reflect the views, at the time of publication, of:

Shell International Oil Products B.V. (SIOP)
and
Shell International Exploration and Production B.V. (SIEP)
and
Shell International Chemicals B.V. (SIC)

The Hague, The Netherlands,

and other Service Companies.

They are based on the experience acquired during their involvement with the design, construction, operation and maintenance of processing units and facilities, and they are supplemented with the experience of Group Operating companies. Where appropriate they are based on, or reference is made to, national and international standards and codes of practice.

The objective is to set the recommended standard for good design and engineering practice applied by Group companies operating an oil refinery, gas handling installation, chemical plant, oil and gas production facility, or any other such facility, and thereby to achieve maximum technical and economic benefit from standardization.

The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where DEPs may not cover every requirement or diversity of condition at each locality. The system of DEPs is expected to be sufficiently flexible to allow individual operating companies to adapt the information set forth in DEPs to their own environment and requirements.

When Contractors or Manufacturers/Suppliers use DEPs they shall be solely responsible for the quality of work and the attainment of the required design and engineering standards. In particular, for those requirements not specifically covered, the Principal will expect them to follow those design and engineering practices which will achieve the same level of integrity as reflected in the DEPs. If in doubt, the Contractor or Manufacturer/Supplier shall, without detracting from his own responsibility, consult the Principal or its technical advisor.

The right to use DEPs is granted by SIOP, SIEP or SIC, in most cases under Service Agreements primarily with companies of the Royal Dutch/Shell Group and other companies receiving technical advice and services from SIOP, SIEP or SIC. Consequently, three categories of users of DEPs can be distinguished:

1) Operating companies having a Service Agreement with SIOP, SIEP, SIC or other Service Company. The use of DEPs by these Operating companies is subject in all respects to the terms and conditions of the relevant Service Agreement.

2) Other parties who are authorized to use DEPs subject to appropriate contractual arrangements.

3) Contractors/subcontractors and Manufacturers/Suppliers under a contract with users referred to under 1) or 2) which requires that tenders for projects, materials supplied or - generally - work performed on behalf of the said users comply with the relevant standards.

All administrative queries should be directed to the DEP Administrator in SIOP.

NOTE: In addition to DEP publications there are Standard Specifications and Draft DEPs for Development (DDDs). DDDs generally introduce new procedures or techniques that will probably need updating as further experience develops during their use. The above requirements for distribution and use of DEPs are also applicable to Standard Specifications and DDDs. Standard Specifications and DDDs will gradually be replaced by DEPs.

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1. INTRODUCTION

1.1 SCOPE

This new DEP gives guidance on minimum requirements for onshore and offshore towers and guyed masts used for telecommunications systems.

Towers or guyed masts normally form part of a total telecommunications network. Hence this DEP should be read in conjunction with DEP 32.71.00.10-Gen., DEP 32.71.00.11-Gen., DEP 32.71.00.12-Gen., and DEP 32.71.00.13-Gen.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIOP and SIEP, the distribution of this DEP is confined to companies forming part of the Royal Dutch/Shell Group or managed by a Group company, and to Contractors and Manufacturers/Suppliers nominated by them (i.e. the distribution code is "F", as described in DEP 00.00.05.05-Gen.).

This DEP is intended for use in oil and gas facilities and in other areas associated with these activities.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements shall be acceptable as regards safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned with the object of obtaining agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party which carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party which manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal shall generally specify the technical requirements. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

The word **structure** indicates either a guyed mast or a self-supporting tower.

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. Other documents referenced in this DEP are listed in (12).

2. TYPES OF STRUCTURE

Structures are used to raise antennas to the necessary height to provide reliable radio communication, radar, and marine navigation services. The structures may be either self-supporting towers or guyed masts. Within each category there are various types, dependent upon the end use, e.g.:

a) fixed;
b) transportable;
c) rapid raise for emergencies;
d) temporary.

Guyed masts are generally lighter and less costly than self-supporting towers. However, a guyed mast usually requires a large area of ground (as a guide: some 80% of the square of its height) to accommodate the guywires and anchors. In urban areas the cost of the land may outweigh savings on the structure. Another disadvantage of guyed masts is the risk of vehicles or cranes damaging the guywires or anchors. This is particularly relevant in industrial sites or in areas where plant and equipment are being transported.

The cost of a tower or mast is approximately proportional to the square of the height. Hence the lowest height shall be selected consistent with achieving the radio link objectives. The cost of an offshore tower also depends on the installation method. A tower concept shall be selected which requires minimum offshore resources during installation and construction.

Other technical equipment such as:

telecommunications equipment shelters,
surveillance cameras, and
security lighting should not be installed on the structure.

However, if this is unavoidable, special attention shall be given to ensuring safe access to such equipment. Specifically this requires:

an adequate working platform, and
a means of equipment removal and replacement, taking account of the weight.

3. DESIGN STANDARDS

The design standards which shall be used are either ANSI/EIA/TIA-222-E 1991 or BS 5950, Part 1, 1990. The wind load shall be determined in accordance with either BS 8100, or Code of Practice 3, Ch. V, Part 2 - 1972, depending on the type of structure. The choice of standard may be dependent upon local regulations, geographic location and the availability of suppliers in the area.

There are other factors involved in calculating the loads on structures which are dependent on the geometry of the structure and other considerations but generally the use of the American Standard will result in a slightly lighter structure than one built to the British Standard. The Contractor shall state in his tender submission which design standards he intends to use and the estimated weight of the structural steel to be supplied.

All elements of the structure shall be hot dip galvanised in accordance with BS 729 or ASTM A 123 or ISO 1459.

4. DESIGN CONSIDERATIONS

4.1 WINDSPEED

Since the wind force on a structure depends on the square of the windspeed, the specification of windspeed is critical in determining the weight, rigidity, and cost of a mast or tower. Every effort should be made to specify the realistic maximum windspeed for the location based on a 3 second gust value. In some countries national or regional building codes may specify design windspeed and conditions.

There are two windspeeds which are important for the design: the maximum windspeed in which twist and sway shall be maintained within the specified limits; and the survival windspeed in which the twist and sway specification shall be temporarily exceeded during extreme gusts but the structure shall return to normal afterwards. These correspond to the 10 and 50 year maximums, respectively.

In both the American and British Standards, the design wind load is based on the 50 year return wind speed for the site. The value is the highest windspeed 10 m above grade for open, level country. However, this value shall be modified by the following variables to make allowance for specific site conditions:

a) an allowance for wind direction, topography and vegetation;
b) a structure height factor;
c) a gust response factor;
d) a drag factor that is a function of the shape of the members and the solidarity ratio of the basic structure.

For offshore towers, a 100 year maximum windspeed may be used to be consistent with the design of the main structure or complex.

4.2 WIND LOADS

The wind load on a tower or mast is the combined effect of the wind pressure on its structural components and on the antennas which it supports.

Antenna manufacturers will normally indicate the wind load for their products at an indicated windspeed. A grid has approximately 65 to 70% less exposed area than a solid dish of the same diameter whilst a radome fitted to a solid dish improves the dynamic wind flow and hence reduces wind pressure. The Supplier is responsible for combining the total load and for any recalculation of the antenna load at the specified windspeed for the structure.

4.3 TWIST AND SWAY

All structures move in the wind to some extent. The directivity of the antennas shall determine the allowable twist and sway. In the absence of specific requirements it is normal to limit these values to 0.5 degrees which should give adequate performance of most radio systems under extreme wind conditions. In the case of offshore towers, the twist and sway is also affected by the platform or substructure and this shall be allowed for in the specification.

Twisting of guyed masts can be reduced by using spreader bars or anti-torque devices between the mast structure and the upper end of the guywires.

4.4 SAFETY FACTOR

The normal safety factor for a new structure should be 1.7. Structures which have been in use for some time may be loaded so that the safety factor has been reduced. Structures with a safety factor lower than 1.4 should be examined in more detail.

4.5 TYPES OF CONSTRUCTION

Guyed masts are usually made from triangular sections whilst self-supporting towers may be triangular or square. Square towers are preferred since the four faces allow more flexibility in mounting directional antennas, such as parabolic dishes, than is possible with a triangular tower.

Towers with tubular legs are sometimes used, particularly for offshore applications where their rigidity allows a single lift installation. Tubulars may be subject to internal corrosion. The difficulty and cost of inspection and correction during the lifetime of the tower should be considered at the time of selection.

Computer programs are used to calculate the stress in each structural member and the leg reactions based on the geometry of the structure. These programs also calculate the safety factor using the normal yield values for structural steel. Tower manufacturers use proprietary programs and are reluctant to supply copies of these to customers. The Contractor should be asked to indicate the safe headload and to provide the engineering design calculations to support this. Depending on foreseeable future requirements, sufficient spare capacity for additional loading should be included. This spare capacity should be at least 50% of initial capacity. These documents should be retained by the Principal in the structure's log.

The flare or vent stack shall not be used as a communication tower because:

a) access to antennas in the case of faults requires shut-down of the facility;
b) damage to the antennas due to heat and corrosive fumes is highly probable;
c) any telecommunication building in the vicinity of the flare stack may be at risk from liquid hydrocarbon carry-over.

Rig derricks should not be used as telecommunication towers. However, if no viable alternative exists, then a specialist study is required prior to such use.

5. TOWER AND MAST FOUNDATIONS

The wind pressure acting on a tower and antennas causes an overturning moment and possible uplift on one or more of the tower legs. The worst case is usually where the wind blows on a corner and reacts on the diagonal faces. With a strong wind, the uplift can easily exceed the dead weight of the tower in one or more legs. The foundations shall be designed to resist this uplift.

For self-supporting towers onshore different types of foundations are used, including:

a) gravity block, where the dead weight of a large concrete block resists the overturning moment purely on its own. It can thus be used in all kinds of soil;
b) pad and chimney, where the weight of an underground concrete pad is enhanced with backfilled rock and soil;
c) concrete raft, which may be subsurface (where the weight of the concrete is increased by backfilling over the whole area under the tower) or on the surface;
d) rock anchors, where chains are grouted into predrilled holes in the rock and then tensioned. A drilling rig is required for this and its mobilisation charge may not be economically justified unless several towers are to be built simultaneously;
e) piled foundations, where soil conditions are poor; these may be also used in swamps and shallow water.

The choice of foundation and the particular design is very dependent on the soil type and a soil test shall be carried out beforehand at the exact location of the proposed tower. The chemical composition of the soil is also important so that measures can be taken to avoid the foundations being attacked by corrosive chemicals. The water table should also be determined at this time, bearing in mind that the level varies with the season. Earth resistivity should also be measured to allow economic design of the earthing. Tower manufacturers can usually provide a range of suitable foundation drawings and specifications based on standard soil conditions and these may need to be modified based on local conditions. Refer to DEP 34.19.20.31-Gen. for detailed information on foundations.

Self-supporting towers offshore can have a significant impact on the structural design of the platform on which it will be located and early involvement of a structural design engineer is necessary.

The footings of the tower may also need to coincide with certain structural points of the platform to carry the additional leg loads of the tower and to counteract the overturning moment. Since this positioning is critical, it is recommended that the tower design and supply be included in the platform specification and be supplied by the platform Contractor rather than attempt to integrate a tower supplied by another Contractor.

The optimum economic width of the tower base is approximately the height of the tower divided by 6.5 but in some locations it is not always possible to make this area available. A standard tower design may then not be possible and it will be necessary to design the structure specifically for that site.

Telecommunication towers and the continuity of services should be included in the risk assessment study for the platform or complex.

For **guyed masts,** the foundation of the base is designed to resist the weight of the mast and the compression force produced by the weight and tension of the guy wires. The guy wires resist the overturning moment. The guy anchors can be either simple gravity blocks or shaped concrete set at depth to use the surrounding soil to resist the dragging forces.

6. LADDERS, WORKING PLATFORMS, AND CABLE/WAVEGUIDE SUPPORTS

The masts and towers shall be designed to be climbed safely and easily by telecommunications technicians who are not professional riggers. Permanent ladders shall be applied. On towers, the ladders shall have a safety cage. On light-weight masts, it is acceptable to have integral climbing steps without cages.

The access ladders, with treads approximately 30 cm apart, shall be permanently and securely attached on the outside of one leg of the tower together with cable and waveguide supports placed in a position that they can be easily reached from within the caged ladders. Ladders in the centre of the tower or on the faces require extra bracing and should not be applied.

Working platforms shall be provided at each antenna level to provide access to the rear of the antennas from a standing position. Additional work platforms shall be provided at other levels on the tower to allow access to future antennas as specified by the Principal. Rest platforms are required adjacent to the ladder at least every 30 m if a work platform is not already provided. Trapdoors should not be installed in the floors of rest or working platforms.

The spacing for cable and waveguide supports should be considered and the Manufacturer's specifications consulted to ensure adequate support under maximum wind speed conditions as well as weight. There should be sufficient space available to accommodate feeders for any future increase in the number of antennas mounted on the structure. For offshore installations, stainless steel material may be considered.

There are numerous methods for clamping waveguides and cables to supports. For waveguides, the clamp should be as recommended by the Manufacturer. The recommended method of attaching cables is by using cable hangers in conjunction with the mounting kit required for the type of tower member used as a support. It is not recommended to use nylon cable ties. If stainless steel wraplock is used, then it should not be attached directly to the structure but over protective sleeves.

7. HAZARD WARNING

As well as obtaining planning permission, which may be difficult in populated areas, it is necessary to notify the relevant civil and military authorities to identify telecommunication structures as aeronautical hazards on NOTAMs (Notice to Airmen). There may be restrictions on the height of a structure which can be installed in the vicinity of an airport. In remote locations it is still necessary to consult with the aviation authorities and Principal's advisers since other factors such as low flying aircraft or helicopter movements for Principal's operations may apply.

If required by local authorities or Principal's aviation specialists, daylight and night-time marking shall be considered. For daylight marking either the tower can be painted with "International Orange-and-White" bands, or high-intensity strobe lights can be used, dependent upon:

a) the availability of mains power;
b) permission from local authorities;
c) the ability to maintain the lighting units in the local environment.

High-intensity strobe lights are preferred since, over the structure's lifetime, this approach is cheaper than repeated painting. There is also less risk of corrosion since the effectiveness of the original galvanising can be reduced by the etch primers used in painting.

For night-time marking, strobe lights or red beacons shall be used. If strobe lights are fitted for daylight visibility, the intensity shall be reduced at twilight and again at night time. If daylight marking of a structure is by painting, then obstruction lighting should use neon tubes in preference to the filament units used in older installations.

The exact specifications for marking towers are found in Annex 14, Chapter 6 of the ICAO Convention - Characteristics of Warning Lights.

During construction, an obstruction light should be installed when the structure reaches the first regulated height and thereafter at subsequent heights. This may be a temporary light which meets the light levels required or it can be part of the permanent installation.

For towers located on offshore platforms with helidecks, omni-directional red lights with a luminous intensity of at least ten candelas should be positioned at the top of the tower, together with intermediate lights of the same luminous intensity placed at 10 m intervals down to the level of the landing deck. Where possible, for night operations, the tower should also be floodlit at helideck level, taking care to avoid dazzling the aircraft pilot when on deck or final approach.

8. PROCUREMENT

There are several options with regard to the contract strategy and the Principal shall decide which one shall be chosen:

a) one turnkey job which is easiest to supervise and manage. However, the Manufacturer/Supplier who in this case also acts as the erection Contractor may not be able to construct the foundations at an economic price due to factors such as mobilisation charges;
b) separate foundations. The foundation is designed and specified by the structure Manufacturer but is constructed by a Contractor who is already active in the area;
c) separate purchase and erection. The structure steelwork is purchased as material and the contract for erection is given to a Contractor already working in the area. Care is required to ensure resolution of problems such as the steelwork not fitting together.

In the case of light masts, standard stock sections form an economic basis for procurement as height can be increased (up to the design maximum) by the addition of sections and increasing the number of guywires. Standard foundations can be used where soil conditions are not extraordinary.

There is little degree of flexibility in self-supporting towers. Manufacturers usually supply towers which are termed "Cut offs", i.e. standard towers which are designed from the top down, enabling the addition of as many sections to the bottom as the final height requires. A customised design is usually only supplied if the design requirements can not be met in any other way.

The tower Manufacturer should have an implemented quality system. This should comply with ISO 9001 requirements or an equivalent internationally recognised quality assurance standard that is acceptable to the Principal. The Principal shall be satisfied that sufficient inspection is carried out as the work progresses.

9. CONSTRUCTION

9.1 SELF-SUPPORTING TOWERS

The foundations of onshore self-supporting towers are often provided through a separate contract. This shall be managed in conjunction with the tower erection contract so that sufficient time is allowed for setting of the concrete and backfilling.

The holding-down bolts and foundation template shall be available before the concrete is poured. Foundation bolts are an integral part of the structure since they transmit the uplift forces from the steel to the concrete. These shall be as originally specified and shall not be damaged in transit. They have to be set in the exact location and at the right level using the foundation template. This is used to ensure the correct mating of the structure to the foundations and, since the foundations are prepared well in advance of erection of the structure to allow curing of the cement, it shall be supplied by the Contractor in sufficient time at the commencement of the project. This template shall not be twisted or damaged. Levels shall be used to ensure the base is horizontal. Shims can be used to bring the alignment within tolerance.

For most concrete foundations the concrete needs to be poured continuously without a break in order not to create interfaces and lose strength. Sufficient backup mixers and staff shall be available on site to achieve this. Quality control shall be applied to the mixing of the cement. Sample blocks shall be taken and compressive tests conducted. The poured concrete shall be 'vibrated' to remove honeycomb and ensure bonding with rebar.

The installation of small towers up to 20 m heights may be undertaken with conventional plant such as cranes, and the employment of ordinary structural riggers. For towers more than 20 m tall, the tower erection Contractor shall use a winch operator, site supervisor and riggers with relevant experience who are used to working together as a team. For large masts and towers several riggers are required.

The working area round the base of the tower shall be cordoned off to restrict access. All personnel working within the restricted area shall be made aware of the danger of falling objects and provided with hard hats and safety or climbing boots. Riggers working at heights shall always work with safety belts and install safety lines around the tower.

The fastest method of erecting a self-supporting tower is by mobile crane but this is expensive, especially in remote areas. On offshore platforms, heavy lift barges are often available which are capable of lifting a complete tower structure. The height to which a tower can be erected by crane is dependent on its maximum boom length. A crane with a telescopic boom is the most useful as it does not involve delays due to booms having to be added as heights increase. Normally the crane is not required to lift more than 2 tonnes of steel. In the event a long-boom crane is not used, it is convenient to use a small mobile crane to lay the tower components out and to install the footings, stubs and the lower panels. A forklift truck can also be used for laying out the tower components.

A "floating derrick" is more generally used for tower erection. The derrick is usually a light steel lattice structure similar to a mast although solid aluminium derricks can also be used. The derrick is supported at its base from the tower legs by means of 4 pulley blocks and ropes and similarly from the top to the highest point of the tower erected. The derrick can now be raised or lowered or leaned to any face or corner of the tower by adjusting the attached ropes which have been secured to the footings of the tower. A winch and a cable is used with the floating derrick to lift either individual tower components or complete tower panels. When each section of the tower is complete the derrick supports are moved up to the next section and the operation repeated.

A winch shall be used which is designed for this task. It should have the following features:

a) "Inching" when the components are in the final stages of lowering on to the section beneath it (known as "landing");
b) "Free Fall" to allow the cable and lifting slings and hooks to be brought rapidly to the ground by gravity without power driving the winch drum;
c) To hold the load when the drive unit is declutched and before the drum brake is applied.

9.2 GUYED MASTS

The foundations for guyed masts are normally simpler than for towers. However, the same considerations as to mixing and pouring of concrete and mating of steelwork apply.

The erection of guyed masts is undertaken by means of a ginpole. In the case of light masts up to 60 m, a powered winch is not essential as sections can be manually lifted by pulley blocks and ropes. However, a powered winch will reduce the time taken and is essential for heavy masts.

Guywires are an integral part of the tower and shall be correctly tensioned to ensure correct load sharing and to make the tower vertical. During erection the guywires shall be tensioned in accordance with tables provided by the mast supplier using dynamometers connected between the lower end of the guywires and the turnbuckles or bottlescrews attached to the anchor plates. It is possible to use one dynamometer and move it from guy to guy but time is saved by using three dynamometers simultaneously. One or more theodolites shall be used to check the verticality.

Guywires shall incorporate a cable bypassing any turnbuckle to act as a safety feature in case of failure of the turnbuckle.

9.3 FINAL COMPLETION

Accessories such as obstruction lights, cables and antennas are installed on the completed structure.

If painting is required inertia reels (safety devices for installation personnel) should be used. In the case of large towers, bosun's chairs do not give access to the internal horizontal members and for these areas the painter should walk on the steelwork with a horizontal safety line. The painting shall be done in accordance with DEP 30.48.00.31-Gen.

Brushes, either conventional or "turks head", are used to apply the paint commencing from the top downwards. "Turks head" brushes, which have bunched bristles on a long handle, allow for fast application but their use involves a higher percentage of paint wastage as compared to conventional brushes. Airspray and airless spray guns should not be used due to the small profile of the steel and the effect of the wind at heights.

Holding-down bolts and all earthing bolts and anchor hardware shall be given a thick coat of corrosion-resistant paint or compound, with particular attention to any areas where the galvanised surface has been damaged and where threads are exposed.

Measurement of the structure earth should be done using standard earth testing methods.

9.4 ACCEPTANCE TEST

The completed structure should be subjected to an acceptance test procedure as described in Appendix A.

10. INSPECTION AND MAINTENANCE

As with all steel constructions, guyed masts and towers shall be given regular inspection and maintenance to ensure that they attain their optimal usable life. With these structures, the safety implications of failure of the structure and damage to surrounding buildings or to personnel in the area are obvious. However, if vital telecommunications are using the facility, failure can also impact on safety in areas remote from the site as well as have economic implications through interruption of important operational and business communications.

Refer to Appendix B and C for suggested inspection and maintenance procedures.

11. DOCUMENTATION

Each structure should be allocated a dedicated file. This file should contain:

a) the structure's specification;
b) any contract, or extracts from any contract pertaining to the structure;
c) design information including:
    1. stress calculations,
    2. permissible head loads,
    3. guy tensions (for guyed masts),
    4. foundation design,
    5. soil test results,
    6. foundation test results - cement tests,
    7. earth resistance test results,
    8. acceptance inspection form;
d) annual maintenance inspection form (and details of any work required); and
e) three-yearly inspection form including details of any work performed.

12. REFERENCES

In this DEP reference is made to the following publications:

NOTE: Unless specifically designated by the date, the latest edition of each publication shall be used, together with any amendments/supplements/revisions thereto.

SHELL STANDARDS

Index to DEP publications and standard specifications	DEP 00.00.05.05-Gen.
Painting and coating of new equipment	DEP 30.48.00.31-Gen.
Plant telecommunications	DEP 32.71.00.10-Gen.
Telecommunication standards	DEP 32.71.00.11-Gen.
Telecommunications for offshore platforms	DEP 32.71.00.12-Gen.
Drilling communications	DEP 32.71.00.13-Gen.
Reinforced concrete foundations and structures	DEP 34.19.20.31-Gen.

AMERICAN STANDARDS

Structural Standards for Steel Antenna Towers and Antenna Supporting Structures	ANSI/EIA TIA-222-E

Issued by:
Electronic Industries Association
Engineering Department
2001 Eye Street
N.W. Washington, D.C. 20006
USA.

Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products	ASTM A 123

Issued by:
American Society for Testing and Materials
1916 Race Street
Philadelphia, PA 19103-118
USA.

BRITISH STANDARDS

Specification for hot dip galvanized coatings on iron and steel articles	BS 729
Structural use of steelwork in building. Code of practice for design in simple and continuous construction: hot-rolled sections	BS 5950: Part 1
Lattice towers and masts	BS 8100
British Code of Practice 3, Chapter V Part 2, 1972	CP 3

Issued by:
British Standards Institution
389 Chiswick High Road
London W4 4AL
United Kingdom.

INTERNATIONAL STANDARDS

ICAO Standards: Annex 14, chapter 6 of the ICAO Convention - Characteristics of Warning Lights	ICAO

Issued by:
International Civil Aviation Organisation
1000 Sherbrooke Street West, Suite 400

Montreal H3A 3R2
Canada.

Metallic coatings; Protection against corrosion by hot dip galvanising; Guiding principles	ISO 1459
Quality systems - Model for quality assurance in design, development, production, installation and servicing	ISO 9001

Issued by:
International Organisation for Standardisation
1 Rue de Varembé
CH-1211, Geneva 20
Switzerland.
Copies can also be obtained from national standards organizations.

APPENDIX A ACCEPTANCE TEST PROCEDURES

1. GENERAL

This Appendix contains the test procedures that should be used when accepting telecommunications structures. The principles of acceptance contained herein should be applied to all types of telecommunications structures. The test procedures encompass the following:

a) Physical inspection of the installation;
b) Application of functional tests to all newly installed, rearranged or modified structures.

The instructions contained in this Appendix are applicable to all personnel, whether employed by the equipment Manufacturer, the Principal, or an outside Contractor. Hereafter in this Appendix, all such personnel are referred to as the "installation force".

2. PURPOSES AND OBJECTIVES

The purpose of this Appendix is to outline the procedures for making the acceptance tests and the results that can be expected from the completion of such tests.

Telecommunications structure acceptance tests are performed to ascertain the following:

a) That a structure's installation, rearrangement, or modification was accomplished in accordance with the engineering specifications covering the job;
b) That all the material associated with the project is in accordance with the pertaining engineering specifications and standards;
c) That all of the required work on the project has been fully completed;
d) That the finished product meets the applicable electrical and safety standards covering the installation and operation of the structure.

The results sought when the acceptance tests have been completed are as follows:

a) Functional reliability of the structure after it is placed in service;
b) Minimal maintenance cost, with an adequate service life period thereafter.

3. ACCEPTANCE TEST PROCEDURE PLAN

The following is a general description of the various elements contained in the procedure plan of the acceptance tests.

The procedure consists of two major programmes of inspection and testing:

a) Physical inspection of the telecommunications structure as installed, rearranged or modified to determine whether the project was completed in accordance with pertaining engineering specifications;
b) Functional testing of all equipment installed, rearranged or modified (such as structure lighting and alarms) to determine whether the equipment meets the functional requirements.

The physical inspection programme should include inspection of the quality of material supplied by the Manufacturer and of the quality of work performed by both the Manufacturer and the installation force. Typical items to be inspected for quality and adherence to engineering specifications on all guyed masts or self-supporting towers are as follows:

a) Tower/mast base;
b) Anchor base (for guyed masts);
c) Anchor rods (for guyed masts);
d) Guy with turnbuckles and clevises (for guyed masts);
e) Tower/mast structure;
f) Painting;
g) Lighting;
h) Antennas;
i) Earthing;
j) Ladder and climbing safety devices.

The functional testing programme of the acceptance procedure incorporates functional testing of the following:

a) Lights;
b) Alarms;
c) Indicators.

4. ACCEPTANCE JOB PLANNING

This section considers the planning aspect of setting an acceptance test programme for all telecommunications structures.

To derive maximum benefit from a programme of acceptance tests, it is first necessary to establish a schedule. The effort expended in developing a total schedule for any given acceptance job prior to commencing the physical inspection and functional test will be of benefit in the following ways:

a) It ensures that all items associated with the job are taken into consideration;
b) It provides sufficient time to schedule the proper acceptance personnel, tools, and test equipment;
c) It permits the acceptance work to proceed in a logical sequence and orderly manner;
d) It provides time for any corrective action to be taken, if necessary;
e) It provides tests and inspections at appropriate times so that corrective action, if necessary, may be taken without undue inconvenience, cost, or time delay to the Principal or installation force.

Scheduling of both the physical inspection and functional testing portions of the acceptance test shall be developed carefully and accurately. Development work should include the following:

a) Establishing start and completion dates for acceptance test;
b) Determining the availability of trained personnel to make the acceptance test;
c) Determine the types and availability of tools and test equipment required for the acceptance test.

Records of structure acceptance must be prepared and completed for the following purposes:

a) To record the progress of acceptance testing;
b) To document the results of the inspection and test to provide a basis for initiating any required corrective action;
c) To furnish the concerned supervision with sufficient evidence of the quality of material and workmanship.

5. ADMINISTRATIVE PROCEDURES

This section outlines the methods and procedures to be used in the administration of an acceptance test programme.

Physical inspection and functional testing should be started as soon as possible after a given segment of construction is completed so that any necessary corrections may be made without undue inconvenience, cost, or time delay to the Principal and installation force.

The following checklists should be used in preparing for, and conducting the physical inspection and functional test on the structure installation:

a) Structure Base and Guy Base Acceptance Checklist;
b) Anchor Rods and Guy W/Turnbuckles and Clevises Checklist;
c) Structure Acceptance Checklist;
d) Structure Lighting Acceptance Checklist;
e) Inspection of Antenna System Checklist;
f) Ladder and Climbing Safety Devices Checklist.

The individual checklists should be arranged in a logical sequence so that acceptance can be done as construction work progresses.

All checklists applicable to the construction of the structure and the functional test should be self-explanatory.

The person performing the acceptance work should enter the completion date and his name in the applicable line for a particular checklist.

If any of the hardware or equipment associated with the structure installation is not covered by this DEP, the acceptance shall be based on guidelines established by the Principal's project engineer.

The acceptance checklist should be analysed by the installation force supervisor and the Principal's project engineer to determine what action, if any, is required for correction.

All defects and failures found during the acceptance shall be corrected and the appropriate forms initialled by the installation force supervisor.

All the inspection forms and notes shall be entered into the structure's dedicated log.

When all the acceptance checklists have been completed and all defects and failures corrected, copies of the checklists shall be provided to the Principal.

APPENDIX B INSPECTION AND MAINTENANCE

1. GENERAL

This Appendix describes inspection and maintenance procedures for telecommunications structures.

For guyed masts, the Principal should secure from the Manufacturer, guy tension information for each mast location and append such information in a table to this procedure. The table should include mast locations, mast heights, number of guys, attaching heights, guy size, guy lengths, and tensions in kilogrammes at a specified temperature. A conversion factor shall be required to convert guy tensions to other temperatures than specified.

2. INSPECTION INTERVAL

All structures should be routinely inspected once each year. A complete inspection should be made on a three-yearly basis.

The following outline serves as a guide for the items to be checked at each of the two inspections.

a) Annual inspection:
   1) Complete relamping (replacement of lamps)
   2) Routine structural inspection; this covers visual inspection only; however, the inspector should note and correct any irregularities that cannot wait for the three-yearly inspection.

b) Complete three-yearly inspection:
   1) Complete relamping
   2) Complete structural inspection; this inspection should include realignment, tensioning and all other items pertinent to the structure's inspection and maintenance report (refer to Appendix C).

3. INSPECTION AND MAINTENANCE REQUIREMENTS

Foundation and guy anchors

All exposed foundation surfaces should be checked for deterioration of any kind. When spalled concrete is evident, concrete mortar should be used for resurfacing the foundation. Excessive smoothing should be avoided when resurfacing as this will tend to increase the chances of spalling. The old surface should be cleaned thoroughly with water before resurfacing. It is also a good practice to bevel the edges of piers protruding above the ground level. All guy anchors should be checked for forward or upward slippage from their original positions. All anchor rods should be checked for bends or corrosion.

Bolted connectors

Visual inspection of bolts is not sufficient. All bolts should be tightened with a standard iron-worker's wrench. The required wrench-handle length depends on the diameter of the bolt being checked, see Table 1. All missing or damaged bolts shall be replaced during the inspection. Where rock anchors have been used in the foundations, these nuts shall be inspected for tightness.

Table 1 Length of wrench handle required to tighten a bolt

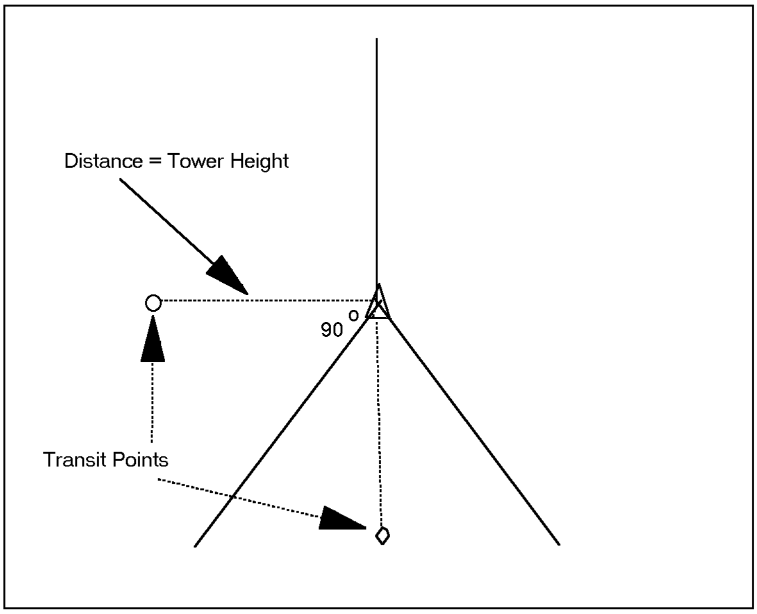
Bolt Diameters (mm)	Handle Length (cm)
10	15
12	20
15	25
18	30
21	35
25	40

Guy tension

The proper guy tension information for a mast should be obtained from the Manufacturer's design drawings or applicable guy tension tables for specific masts. The guy tensions at the various levels for a mast may not be the same; they are dependent on the size of the guy and the angle the guy makes with the horizontal. In most cases, if the measured tension is within 10% of the specified value, it shall be considered adequate. For a four-guyed mast, however, the opposing tensions should be within 10% of each other.

A complete guy tension check should be made in conjunction with every mast realignment inspection since realigning the mast shall necessitate changing the tensions. Dillon shunt-type dynamometers, or equivalent, should be used which have been accurately calibrated. The guy tension checks should be made when there is no appreciable wind and during moderate temperatures. The air temperature surrounding the guys should be measured with the thermometer included with the dynamometer so that compensations for thermal expansion of the wire can be made. Appropriate factors for setting the tension at various temperatures are given with the Dillon shunt-type dynamometer.

Figure 1 Transit position for mast re-alignment



Mast alignment

Two transits (dumpy levels or similar) are needed for inspecting the mast alignment. These transits should be 90 degrees apart and at a distance from the base of the mast approximately equal to its mast height as shown in Figure 1.

Figure 2 Allowable deviation between two adjacent guy levels

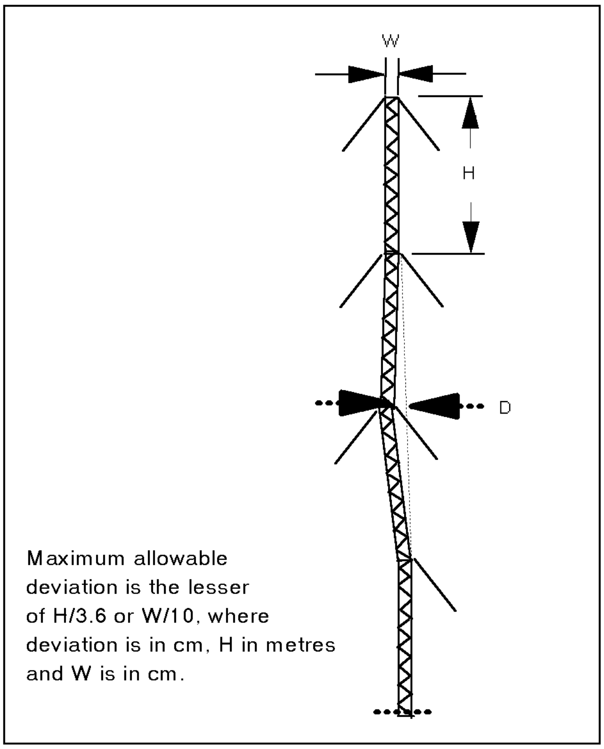
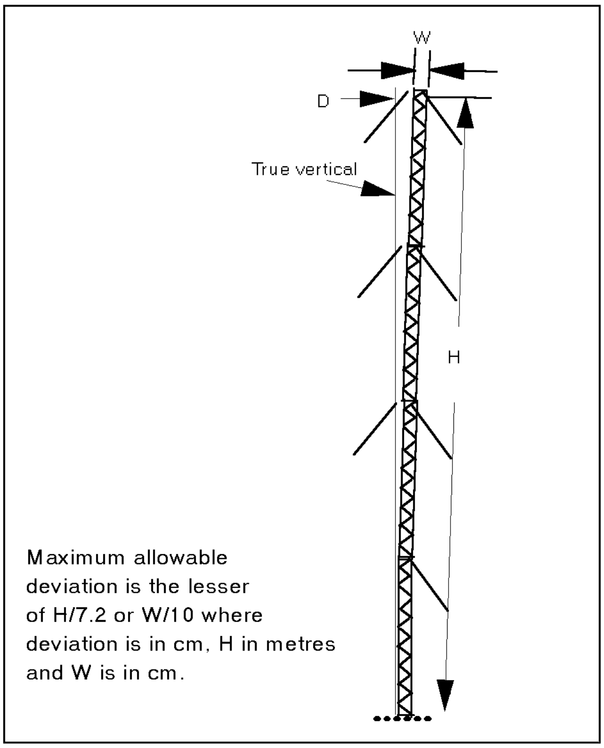


Figure 3 Overall allowable deviation for a guyed mast



The inspector should use the information in Figures 2 and 3 with his transit checks to decide if the deviation is within specified limits. If the deviation requires correcting, the inspector should adjust the appropriate guy tensions to bring the tower to a plumb position. The transits can be left in place for periodic checking during the realignment. The guy tensions shall be within the specified values when the realignment is completed.

Corrosion

All exposed steel in the structure members, anchor rods, clamps, turnbuckles, antennas and reflectors, supporting structures, or any other exposed metal within the structure assembly should be checked for corrosion and rust and affected areas should be cleaned and treated.

The corroded area of painted steelwork should be cleaned with a wire brush or heavy sandpaper and covered with a red primer and coated to match the original colour.

The corroded area of galvanized steel should be cleaned with a wire brush and two coats of a cold galvanizing component applied.

Any evidence of corrosion due to the contact of two dissimilar metals should be called to the attention of the Principal for further action. Such steps as necessary to arrest this corrosive action must be taken at once.

Repainting

Under normal conditions, paint can be expected to have a life of 4 to 5 years. More frequent intervals are sometimes required if the air obstruction markings are faded. For obstruction purposes, however, only the outside members of the structure need be painted with International Orange-and-White. If most of the paint on the structure is brittle and crumbles when scraped with a knife, the whole structure should be repainted. A good criterion on when to completely repaint a structure would be when the area of bad spots runs to more than 20% of the area of the structure, except that International obstruction markers must always be distinct.

Lighting (Relamping)

All lamps should be replaced annually. All globes and lenses should be checked for breaks and dirt at the time of lamp replacement. On periodic visits to telecommunication sites, obstruction lighting should be checked.

Inspection and maintenance forms

Forms should be used to record inspection and maintenance work performed on each structure, and a copy of each inspection report should be placed in the structure log. See Appendix C.

Entries concerning the operations and maintenance of antennas shall be made in the technical log of the station.

APPENDIX C SAMPLE STRUCTURE INSPECTION AND MAINTENANCE REPORT

Submitted: ...., 19
Structure location: ....
Manufacturer:...
Type tower and height:...
Inspected by:...

Weather conditions
Date: Temperature:..
Wind direction and speed: ....

General condition of tower:
The following tools should be available:

1 - Dillon shunt-type dynamometer, or equivalent
2 - Transits
1 - Pair binoculars - 7 x 50
- Crescent wrenches (15 cm to 45 cm sizes)
- Screwdrivers

NOTE: In filling out this form, the inspector should indicate where the fault was found and what was done for correction. If some items within this report do not apply to a particular structure, the inspector should so indicate by writing "Does not apply" in the space provided.

1. Concrete base and anchors

Check for signs of spalling and fracture.

Base...
....

Anchor..
....

2. Bolted connections

Check for missing and loose bolts. Replace all missing bolts and tighten all bolts with the proper size wrench. Indicate where the bolts were loose or missing.

Connection bolts ....
....

Splice bolts...
....

3. Structural members

Check for fractures, bends, and faulty welds.

Legs...

Bracing...
....

Antenna mounts..
....

Star mount..
....

Stub towers ....
....

Ice guard (where applicable)...
....

Other...
....

4. Corrosion in members

Check for any signs of corrosion.

Legs..
....

Bracing..
....

Antenna mounts...
....

Star mount...
....

Stub towers...
....

Ice guard (where applicable)..
....

Other..
....

Check for signs of galvanizing flaking and rust.

Check for paint flaking and signs of rust.

5. Guy plates, guy rods, clamps

Check for fractures, bends and corrosion.

Guy plates...
....

Guy rods..
....

Clamps..
....

6. Earthing of base and anchors

Check for looseness of all earthing connections

Base..
....

Anchors...
....

7. Lighting

- Check for any broken or cracked globes or lenses
- Clear any fixture drain holes
- Check for broken spring fasteners on fixtures
- Check for burned out lamps (If operated by photo-cell, cover cell to check lamps)
- Replace all lamps
- Check conduit clamps for tightness
- Check conduit and junction boxes for corrosion and loose connections
- Check for condensation inside junction boxes
- Check to see if all gaskets, covers and cover screws are in place
- Check for looseness of electrical connections
- Check flasher timing (30 Flashes/minute with flashes 1-1/3 second on and 2/3 second off)
- If a mechanical flash unit, oil the motor bearing and cam surface of the flasher unit.

8. Guys

- Check for loose wire rope clips
- Check for proper "deadends"
- Check for signs of corrosion or wear on guy plates
- Look with binoculars for broken strands and insulators
- Check for slippage at insulator connections
- Check turnbuckles for wear and rotation (Turnbuckles should not be allowed to rotate)
- Check tension of all guys with Dillon shunt-type dynamometer, or equivalent. Record information in Appendix D, Table 1.

9. Mast re-alignment

Check mast re-alignment and record information in Appendix D, Table 2.

10. Painting

- Check to see if orange and white shows clearly from a distance
- Check for paint flaking and fading colours.

11. Check for the following:

- Loose antenna (or reflector) attachments
- Damaged heater wiring
- Loose stabilizing rods.

12. Transmission lines

- Check lines for damage and dents
- If line is flanged, check for signs of missing or loose clamps
- If line is pressurized, check for any signs of pressure leaks
- Check for loose line supports, restrainers or wraplock connections
- Check for any contact between transmission lines and structure that might cause wear or cutting to the line
- Check for any missing protective sleeves under all wraplock attached to transmission line.

13. General

Time of inspection: ....Start.....................Finish ....
Number of man-hours: ....On tower..........................Travel ....
Materials installed:..
....
Repairs recommended:..
....
General remarks: ....

APPENDIX D GUYED MAST RE-ALIGNMENT AND TENSIONING DATA FORM

Date:..........................

<u>Weather conditions</u>

Guy temperature:..........................Wind speed & direction:...................................

Cloudy or clear: ....Hour of day:...

Table 1 Tensions

Design tensions							
Guy A		Guy B		Guy C		Guy D	
Measured tensions							
Guy A		Guy B		Guy C		Guy D	
Original	Corrected	Original	Corrected	Original	Corrected	Original	Corrected

Table 2 Deflections

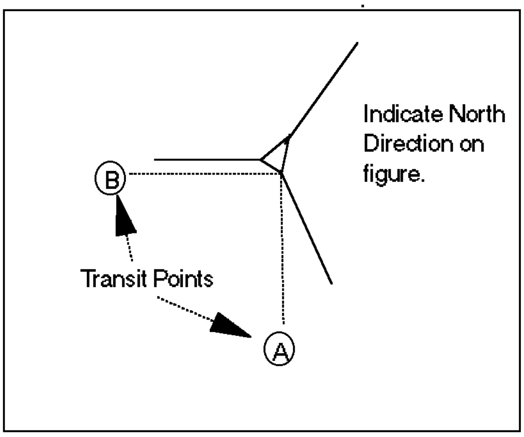
Transit Point A				Transit Point B			
Adjacent guy level deflections (cm)		Overall deflections (cm)		Adjacent guy level deflections (cm)		Overall deflections (cm)	
Measured	Corrected	Measured	Corrected	Measured	Corrected	Measured	Corrected

Allowable deflections (cms)	
Adjacent guy levels	Overall
W/ 10 =	W/ 10 =
H/ 3.6 =	H/ 7.2 =

Where for guys:
W = width of mast, in centimetres
H = distance between adjacent guys, in metres

Where for overall measurement:

H = height of mast in metres



NOTES:

1. Drawings provided by the mast Manufacturer, or the guy tension tables for specified masts, shall provide the recommended guy tensions at the various guy levels for each mast.

2. If the mast is plumb and an adjustment is required in the guy tension at a given level, $^1/3$ of the additional (or less) required tensions should be placed in each guy at that level so that the mast shall remain plumb. Tensions should be within 10% of the specified (recommended) values.

3. When calculating the maximum allowable deflection, w is the width of the mast in cm, h is the height on the mast between two adjacent guy levels in metres, and H is the overall mast height in metres.

4. The degrees of deflection as read on the transit can be converted to cms by the following formula:

   Deflection (cm) = 1.74 (Degree deflection) $(h^2 + x^2)^{1/2}$

   where h = height on mast to measured deflection and x = horizontal distance from transit to the mast, both in metres.

5. It is not necessary to record deflections at each guy level. Record the overall deflection (Top of Mast) and the guy level deflections at points in question as determined by the transit readings.