Eskom	Standard	Technology

Title: **STANDARD FOR THE ERECTION OF STEELWORK AND MICROWAVE TOWERS IN ESKOM TRANSMISSION SUBSTATIONS**

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Content

Page

1. Introduction 4
2. Supporting clauses 4
   - 2.1 Scope 4
   - 2.2 Normative/Informative References 4
     - 2.2.1 Normative 4
     - 2.2.2 Informative 5
   - 2.3 Definitions 5
     - 2.3.1 General 5
     - 2.3.2 Disclosure classification 6
   - 2.4 Abbreviations 6
   - 2.5 Roles and responsibilities 6
   - 2.6 Process for monitoring 6
   - 2.7 Related/supporting documents 6
3. Construction 6
   - 3.1 General 6
   - 3.2 Assembly 7
   - 3.3 Erection 7
     - 3.3.1 Procedure 7
     - 3.3.2 Storage and Handling 7
     - 3.3.3 Safety during Erection 7
   - 3.4 Setting-out 8
   - 3.5 Alignment 8
   - 3.6 Bolting 8
     - 3.6.1 Bolt/nut combinations 8
     - 3.6.2 Multiple bolt classes and diameters 8
     - 3.6.3 Parts 8
     - 3.6.4 Methods of tightening 9
     - 3.6.5 Bolt length 9
     - 3.6.6 Avoidance of excessive stresses during construction 9
   - 3.7 Corrections 9
   - 3.8 Grouting 10
     - 3.8.1 Responsibility 10
     - 3.8.2 Preparation 10
4. Tolerances 10
   - 4.1 General Steelwork 10
     - 4.1.1 Verification of Dimensions 10
     - 4.1.2 Methods of Specifying Tolerances 10
     - 4.1.3 Degrees of Accuracy 12
     - 4.1.4 Precedence where Tolerances Conflict 12
     - 4.1.5 Fabrication and Assembly Tolerance 12
     - 4.1.6 Rounding up of PDs 12
   - 4.2 Tolerances on Dimensions and Accuracy of Erection 12
     - 4.2.1 Rolled Sections 12
     - 4.2.2 Other tolerances 12

4.3 Corrosion protection 15
4.3.1 Blast Profile 15
4.3.2 Weld Cracks and Laminations 15
4.3.3 Mixing and Thinning 15
4.3.4 Dry Film Thickness 15
5. Authorization 15
6. Revisions 15
7. Development team 16
8. Acknowledgements 16

Figures

Figure 1: A Manufactured Component (SANS 1200 A – 1986) 11
Figure 2: A Manufactured Component (SANS 1200 A – 1986) 11

Tables

Table 1: Bolt tension for torque setting 9
Table 2: PD Qualifications (SANS 1200 H- 1990) 13
Table 3: PD Qualifications (SANS 1200 H- 1990) 14

1. Introduction

The purpose of this document is to assist persons involved in the erection of steelwork and microwave towers to perform this function more easily and efficiently to the specification set out by Eskom.

2. Supporting clauses

2.1 Scope

This specification sets out Eskom's requirements for the erection of substation steelwork structures. This specification shall apply throughout all Eskom Transmission substations.

2.1.1 Purpose

This document standardises the fabrication requirements for the steelwork to be used in Transmission substations.

2.1.2 Applicability

This specification shall apply throughout all Eskom Transmission substations.

2.2 Normative/Informative References

2.2.1 Normative

The following documents contain provisions that, through reference in the text, constitute requirements of this specification. At the time of publication, the editions indicated were valid. In cases of conflict, the provisions of this specification shall take precedence. Parties using this specification shall apply the most recent edition of the documents listed below.

[1] BS 5531: Code of practice for safety in erecting structural frames

[2] TRMSCABG8: Transmission-Corrosion protection of new and weathered steel powerline structures

[3] SANS 121:2000: Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods

[4] SANS 10044: Code of Practice for Welding: 7 parts.

[5] SANS 10064: Preparing of steel surfaces for coating

[6] SANS 10104: Hand and guard rails (safety aspects).

[7] SANS 1200: Series of standardized specifications for Civil Engineering Construction.

[8] SANS 1700 SERIES: ISO metric bolts, screws and nuts (hexagon or square) (coarse thread free fit series)

[9] SANS ISO 9000 series: Code of Practice for Quality Systems.

[10] SANS 10162: The structural use of steel: parts 1 and 2.

[11] SANS 14713: Protection against corrosion of iron and steel in structures-Zinc and aluminium coatings-Guidelines

[12] SANS 455: Covered Electrodes for the manual arc welding of carbon and manganese

[13] SANS 2063: Metallic and other inorganic coatings-Thermal spraying-Zinc, aluminium and their alloys

[14] SANS 1431: Weldable structural steels

[15] South African Institute of Steel Construction Structural Steel Tables.

2.2.2 Informative

[16] South African Steel Construction Handbook, Fifth Edition 2005, The South African Institute of Steel Construction.

2.3 Definitions

2.3.1 General

Definition	Description
Acceptable / Approved (approval)	Acceptable to / Approved (Approval) by Eskom.
Agreed	Agreed in writing by Eskom
As detailed	As detailed on the drawings.
Authorized / ordered / rejected	Authorized / ordered / rejected by Eskom.
Bolt grade designation	The grade designations have the following significance: the first number multiplied by 100 is the minimum tensile strength of the bolt material in MPa and the second number multiplied by 10 is the ratio (expressed as a percentage) between the stress at permanent set of 0.2 per cent (yield stress) and the minimum tensile strength. Thus a Grade 4.6 bolt has a minimum tensile strength of 400 MPa and minimum yield stress of 60 percent of 400, viz. 240 Mpa.
Coat	A single layer of corrosion – protection material.
Coating System	The method and degree of surface preparation, the type of coating, the number of coats and their thickness, the method of application of the coats and the requirements of the completed system.
Designated	Shown on a drawing or otherwise specified by Eskom or, in relation to an item scheduled in the tender document, descriptive of an item to be priced by a tendered.
Deviation	The difference between the actual (i.e. measured) size or position and the specified size or position.
Hot – dip (galvanized) coating	A coating of zinc – iron alloy layers (or such layers and a layer of zinc) obtained by dipping a prepared iron or steel article in molten zinc.
Hot patching solder	A solder alloy that is based on zinc that includes other compatible elements and that is such that the melting point of the solder is low enough to allow the making of satisfactory repairs to a to-dip zinc coating.
Indicated	Indicated in or reasonably to be inferred from the contract, or indicated in writing by Eskom.
Instructed / Directed / Permitted	Instructed / directed / permitted by Eskom
Normal temperature	Denotes a temperature between 15°C and 32°C.
Permissible deviation (PD)	The specified limit(s) of deviation.
Satisfactory	Capable of fulfilling or having fulfilled the intended function.

Definition	Description
Service	Any pipeline, duct, cable or overhead wire for conveying, as appropriate, any fluid (including stormwater and gas), or electricity or other form of energy for lighting or power, or telecommunications transmissions.
Submitted	Submitted with the tender or submitted to Eskom as appropriate.
Tolerance	The range between the limits within which a size or position must lie.

2.3.2 Disclosure classification

Controlled disclosure: controlled disclosure to external parties (either enforced by law, or discretionary).

2.4 Abbreviations

Abbreviation	Description
ASTM	American Society for Testing and Materials
BM	Bench mark
BS	British Standards
CP	British Standard Code of Practice
DFT	Dry film thickness
HDG	Hot – dip galvanizing
SANS	South African National Standards
SMTM	Standard Methods of Testing Materials for the Department of Transport Affairs of the Republic of South Africa.
PD	Permissible Deviation

2.5 Roles and responsibilities

This standard must be used by substation designers who are involved in the design of steel structures. The standard shall be issued as part of technical documents for tender enquiries.

2.6 Process for monitoring

None

2.7 Related/supporting documents

None

3. Construction

3.1 General

a) The contractor shall, at his own expense, supply and provide all the Constructional Plant, Temporary Works, materials for both temporary and permanent works, labour and supervision, transport to or from the site and in and about the Works and everything required for the construction, completion and maintenance of the Works.

b) The Contractor shall ensure that all the foregoing constituent parts of the Works are to the standard and quality specified in this document or where not specified to the highest available and shall also ensure they are suitable for the purpose intended by Eskom.

c) The Contractor shall be responsible for the strength and quality of all materials used and workmanship employed and for the stability of the permanent works and the temporary works and the fact that the Employer has not objected during the construction period to any materials and/or workmanship employed by the Contractor and even though such materials and/or workmanship have been inspected by the Supervisor shall not relieve the Contractor of such responsibility.

3.2 Assembly

The component parts shall be so assembled that:

a) the whole and all parts of the finished structure are within the tolerances specified in clause 9,

b) no member is bent, twisted or otherwise damaged, and

c) the specified cambers are obtained.

3.3 Erection

3.3.1 Procedure

a) The Contractor shall submit to Eskom, for general scrutiny, information, review and approval acceptance, full details of the erection procedure and methods of erection.

b) Every contractor performing construction work shall before the commencement of any construction work and during construction work, cause a risk assessment to be performed by a competent person appointed in writing and the risk assessment shall form part of the health and safety plan to be applied on the site and shall include at least the identification of the risks and hazards to which persons may be exposed to;

i. the analysis and evaluation of the risks and hazards identified;

ii. a documented plan of safe work procedures to mitigate, reduce or control the risks and hazards that have been identified;

iii. a monitoring plan; and

iv. a review plan.

3.3.2 Storage and Handling

a) All structural steelwork at any location or in transit, shall be handled, stored and stacked so that it is not subject to damage or excessive stress and is kept clean and dry.

b) Fasteners and similar small fittings shall be stored under cover and in dry conditions.

3.3.3 Safety during Erection

a) While it is incumbent on Eskom to ensure that the structure or elements thereof can be erected without loss of stability or without overstress, the Contractor shall be responsible for the maintenance of safety standards during erection.

b) Adequate temporary bracing, stiffening or supports shall be provided by the Contractor during erection for as long as they are required to protect the structure from:

i. the possibility of loss of stability or overstressing of the structure in its partly completed state, and

ii. the imposition of loadings (in particular those due to erection equipment or procedures) that are more severe than those that the completed structure is intended to sustain.

c) All temporary works provided for this purpose shall be left in position until such time that erection has sufficiently advanced for them to be no longer required.

d) The contractor shall ensure that connections for temporary bracing, members or cleats and additional holes used to facilitate handling or erection do not weaken the permanent structure or impair its serviceability. If there is any doubt, the Contractor shall ask Eskom for instructions.

3.4 Setting-out

Before commencing with erection of steelwork on Site, the Contractor shall check that the setting-out and the levels of holding-down bolts and of concrete foundations, beam faces and columns are in accordance with the drawings provided and shall report any discrepancies immediately to Eskom.

3.5 Alignment

a) All pockets that are to receive holding down bolts, fittings or steelwork shall be cleaned out immediately before erection is commenced.

b) Each part of the structure shall be aligned as soon as possible after it has been erected.

c) Members shall not be permanently connected until enough of the structure has been aligned, levelled, plumbed and temporarily connected to ensure that they will not be displaced during erection or alignment of the remainder of the structure.

d) All matching holes for fasteners shall so register with each other that the fasteners can be inserted freely through the assembled members in a direction at right angles to the faces in contact.

e) Drifting to align the holes shall be so done that the metal is not distorted and the holes are not enlarged. Holes that cannot be aligned without enlargement shall be cause for rejection unless enlargement by reaming is specifically approved by Eskom.

3.6 Bolting

3.6.1 Bolt/nut combinations

a) Bolts and nuts combinations shall have the minimum requirements of;

   i. class 4.8 bolts or screws with class 4 nuts in accordance with SANS 1700-5-2; or

   ii. class 8.8 bolts with class 8 nuts in accordance with SANS 1700-5-2.

b) Any bolt assembly that is damaged during tightening shall be replaced.

3.6.2 Multiple bolt classes and diameters

Bolts of different classes and same diameter shall not be used on the same structure.

3.6.3 Parts

a) The parts to be joined shall be firmly drawn together. Grade 4.8 bolts and Grade 8.8 bolts in shear and bearing type connections shall be tensioned by hand to the limit of the torque that can be applied by the use of a standard podger spanner.

b) High tensile bolts for major tension type or moment type connections and where fatigue is a consideration, shall be tightened to a tension of 75% of the proof load stress of the bolt, as indicated in Table 1.

Table 1: Bolt tension for torque setting

Bolt size	Stress Area (mm^2)	Bolt Tension (kN)	
		Grade 4.6	Grade 8.8
M12	84,3	25	51
M16	157	47	94
M20	245	74	147
(M22)	-	-	-
M24	353	106	212
(M27)	-	-	-
M30	561	168	337
M36	817	245	490

*Sizes shown in brackets are non-preferred.

3.6.4 Methods of tightening

The following methods of tightening to the required torque will be acceptable.

3.6.4.1 Turn of nut method

All plies of the connection at all bolt positions shall be pulled into close contact (snug tight). Tighten bolt and nut to finger tight state where-after it is subjected to a 1,25 turn on a full grip length.

3.6.4.2 Torque control method

This method is only acceptable if the torque wrench is calibrated using a representative sample and its conditions remain stable. The torque setting shall correspond with prescribed tension settings in Table 1.

3.6.4.3 Proprietary load indicating devices

a) All connections shall be pulled to their snug tight conditions before proceeding with final tightening. This method is not preferred as it does only indicate that the particular bolt was once tensioned to its required load. It could be used however, to set the tightening device for the torque control method.

b) An accurate direct measurement procedure shall demonstrate that the bolts are being tightened to the required tension.

3.6.5 Bolt length

a) The length of each bolt shall be such that after the bolt has been tightened, at least one thread projects through the nut and at least one full thread (in addition to the thread uncut) remains clear between the nut and the unthreaded shank.

b) Unless otherwise stated, the maximum protrusion beyond the nut shall be 25mm.

3.6.6 Avoidance of excessive stresses during construction

Structures, composite units and bolted assemblies that comprise component parts, shall not be subjected to excessive stresses during the assembly, fabrication or erection process.

3.7 Corrections

a) Drift pins, jacking equipment and the like shall not be used to bring improperly fabricated members into place.

b) A moderate degree of reaming and cutting may be employed to correct minor misfits only if, in the opinion of Eskom, this will not be detrimental to the strength or appearance of the steelwork.

c) Except if allowed in terms of 7.1.4 c), no burning of holes in steelwork shall be permitted without the written consent of Eskom.

3.8 Grouting

3.8.1 Responsibility

a) Unless otherwise specified, grouting or bedding will be carried out by others to Eskom's specification and approval.

b) All grouting shall be completed before the structure can be mounted.

3.8.2 Preparation

a) The Contractor shall ensure that no bedding or grouting is carried out until the structure has been properly aligned or a sufficient number of bottom lengths of stanchions have been aligned, levelled, plumbed and adequately braced by the Contractor by means of other structural components that have been levelled and are securely held by their permanent connections.

b) Steel wedges, packing plates or other levelling devices of adequate strength and rigidity shall be used to support the steelwork.

c) Before grouting, the space and all pockets under the steel shall be cleared of all debris and free of water.

d) Packer plates shall be galvanized in accordance with 7.3, with a minimum size of 30% of the plan area of the base plate.

4. Tolerances

4.1 General Steelwork

4.1.1 Verification of Dimensions

a) Verification of dimensions shall be carried out.

b) Unless otherwise specified, the effects of temperature on the structure must be considered when measurements are made during setting out, erection or subsequent dimensional checks. The reference temperature shall be 20°C and the tension in the tape shall be 70N;

c) For erection within 3 hours after sunrise or within 3 hours before sunset, or at such time when, in the opinion of Eskom, the effect of the sun is minimal. Distortion caused by the sun's rays striking one side of a member or structure shall be taken into account, and measurements shall be made only at times when this effect is non-existent or of no consequence.

4.1.2 Methods of Specifying Tolerances

Tolerances may be specified in several different ways as indicated in Figure 1, in the case of Linear dimensions, position, verticality, level, squareness and bow, permissible deviations shall, unless otherwise stated, be both positive and negative and of equal numerical value. This facilitates the insertion of correct tolerance values and allows for deviations occurring in opposite directions.

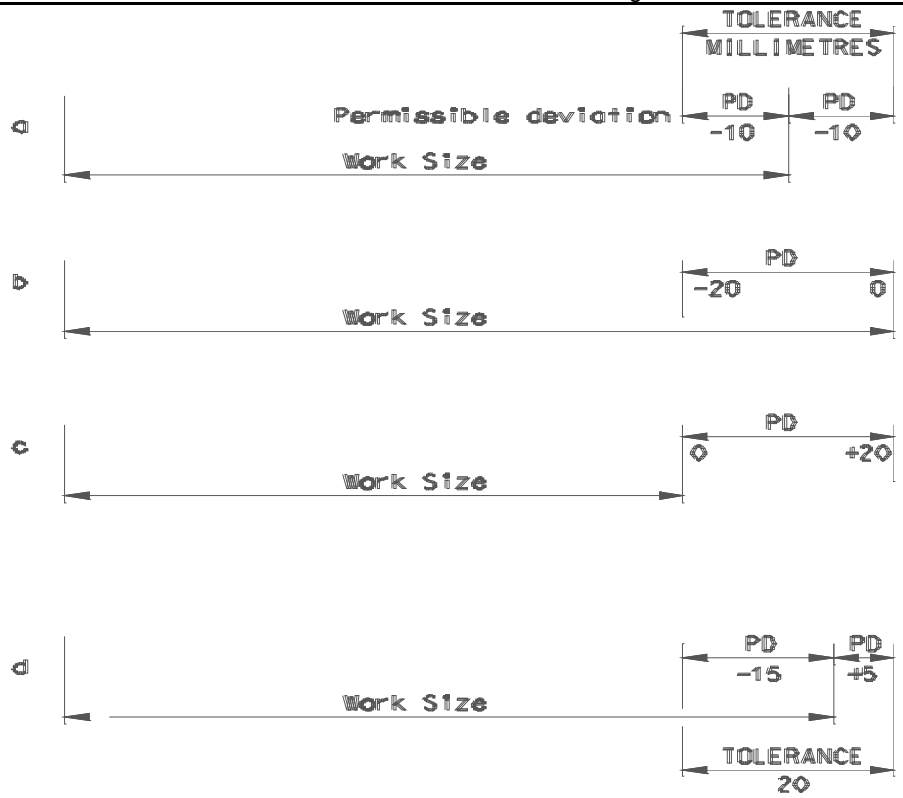


Figure 1: A Manufactured Component (SANS 1200 A – 1986)

In certain cases permissible deviations (PD) may be positive or negative but not equal (See Figure 1)

Deviations such as twist and bow edge do not usually have any positive or negative sense. In such cases the permissible deviation is assumed to be positive and is equal to the tolerance in numerical value. Figure 2 shows, on a larger scale, the deviation that may be found on site compared with the permissible deviation specified for the placing of a column.

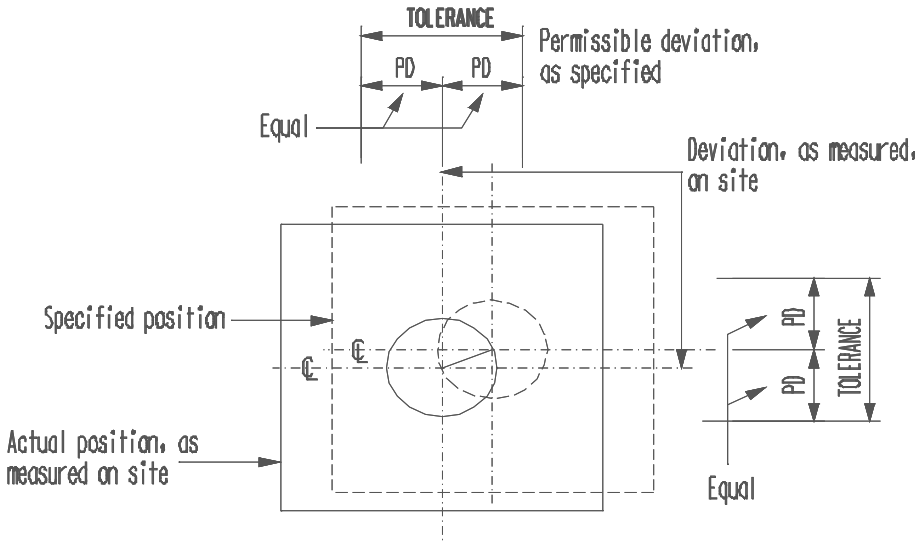


Figure 2: A Manufactured Component (SANS 1200 A – 1986)

4.1.3 Degrees of Accuracy

a) The Contractor shall construct each of the various parts of the Works to the degree of accuracy specified. The degree of accuracy may be one of the following:

i. Degree of Accuracy III is used where a high degree of accuracy is unnecessary, e.g. mass foundations.

ii. Degree of Accuracy II is for what is commonly called “good work”

iii. Degree of Accuracy I where the use of special, as opposed to normal, methods of materials (or both) is warranted despite the probability of higher costs than will be incurred by the application of Degree of Accuracy II.

Except where another degree of accuracy is specified in a standardized specification or the project specification or given on the drawings, Degree of Accuracy II shall apply.

4.1.4 Precedence where Tolerances Conflict

Where a tolerance given in any specification covering an early stage of construction conflicts with any tolerance given in a specification covering a subsequent stage of construction, the tolerance applicable to the subsequent construction stage shall take precedence.

4.1.5 Fabrication and Assembly Tolerance

The permissible deviation on the dimensions of components (such as gussets and cross-bracing) and on the location of bolt holes in components and elements of a structure shall be 12 mm, (See also 5.1.4). Holes for connections shall be aligned as specified in Specification for the Erection of Steelwork in Eskom Transmission Substations, clause 6.5.

4.1.6 Rounding up of PDs

All calculated permissible deviations shall be rounded up to the next whole millimetre.

4.2 Tolerances on Dimensions and Accuracy of Erection

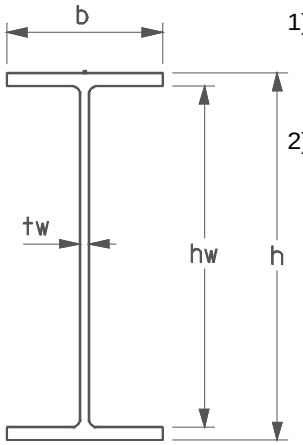
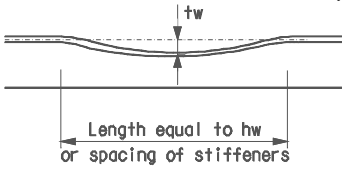
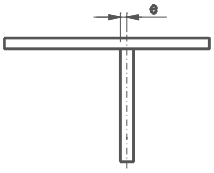
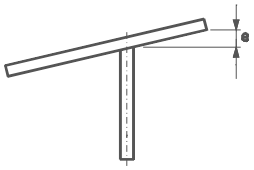
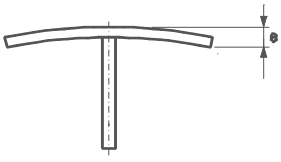
4.2.1 Rolled Sections

The tolerances on cross-sectional dimensions of rolled section shall be as specified in the latest issue of structural steel tables of the South African Institute of Steel Construction.

4.2.2 Other tolerances

The tolerances on all dimensions (other than of rolled sections), accuracy of erection, location of holding-down bolts, location of column bases, levels, etc, shall be as given below in Tables 4 and 5.

Table 2: PD Qualifications (SANS 1200 H- 1990)

Item	Permissible deviation, mm Degree of accuracy		
	III	II	I
a) Cross sections			
 1) Width of Flange (b)			
b ≤ 400mm	*	± 4	*
b > 400mm	*	± 6	*
2) Depth (h)#			
h ≤ 1000mm	*	± 3	*
h > 1000mm	*	± 5	*
 3) Flatness of web (δ			
$t_w < h_w/150$	*	Lesser of 8 or $h_w/150$	*
$t_w < h_w/150$	*	Lesser of 8 or $h_w/150$	*
 4) Off centre (e)	*	6	*
 5) Tilt of flange (α)	*	b/200	*
 6) Warpage of flange (β)	*	b/200	*

***as otherwise stated on the drawings**

#all indicated permissible deviations from the specified depth (h) may occur simultaneously and be cumulative.

Table 3: PD Qualifications (SANS 1200 H- 1990)

Item	Permissible deviation, mm		
	Degree of accuracy		
	III	II	I
a) Length			
1) The PD of the length of a member from designated length.....	*	+1 -2	*
2) For such members as trusses and lattice girders, these tolerance apply to the member as a whole. The lengths of component parts shall be such that the member can be properly assembled with a PD of.....	*	+1 -2	*
b) Accuracy of erection			
1) Out of plumb over any vertical height (H).....	*	Lesser of 50 or H/500	*
2) Displacement of centerline of column in structures of more than one storey in height from designated position (total structure height, H).....	*	Greater of 6 or H/1000	*
c) Straightness (or specified shape) after erection			
1) For compression members and beams (other than purlins and sheeting rails) of length L, between points that are to be laterally restrained.....		Greater of 3 or L/1000	*
2) For other members of length L.....		Lesser of 25 or L/500	*
3) Handrails.....	*	++	*
d) Location of holding-down bolts			
1) The centerline of a holding-down bolt from its designated location in plan.....	*	±3	*
2) The top of the bolt from its designated elevation.....	*	+5 -3	*
e) Column bases	*	±3	*
Designated level and plan position of column bases.....			

* As otherwise stated on the drawings.

++ Handrails shall be visually straight (or of specified shape)

4.3 Corrosion protection

4.3.1 Blast Profile

Blast profile limits shall be:

a) for a 60 um profile : ±15 µm

b) for a 100 um profile: ± 25 µm

4.3.2 Weld Cracks and Laminations

Significant defects that appear after surface preparation of steelwork shall be repaired in accordance with an approved procedure, taking into account the structural integrity of the affected component.

4.3.3 Mixing and Thinning

Any deviation from the coating manufacturer's recommendation for the proportions of components in multipack mixes, or for the degree of thinning or for intercoat intervals shall be in accordance with Eskom's written instructions, as approved by the manufacturer.

4.3.4 Dry Film Thickness

a) At least 90% of all coating thickness shall be more than required thickness as stated in Table 1. Up to 10% of all readings may be below the specified thickness but may not be less than 70% of the specified thickness. Where dry film thicknesses are less than those specified, remedial action shall be taken to build up the thickness to that specified.

b) DFT in excess of the specified thickness shall not constitute a reason for rejection if the paint or galvanizing film is sound in all aspects.

c) Owing to delayed solvent release, coatings of solvent-borne paints will shrink over a period of time, resulting in a lower film thickness. DFT measurements taken at times beyond the 7 day stipulation in 10.4 shall not constitute a valid claim against the original satisfactory and documented execution of the work.

d) The method used to measure DFT and the significance of the readings shall be agreed upon between the parties prior to commencement of work.

5. Authorization

This document has been seen and accepted by:

Name and surname	Designation
P Tlhatlhetji	Senior Manager Substation Engineering
D Senekal	Senior Technologist Substation Engineering

6. Revisions

Date	Rev	Compiler	Remarks
Aug 2015	1	B Hajee	First issue

7. Development team

The following people were involved in the development of this document:

- Bilal Hajee

8. Acknowledgements

Not applicable.