



Construction of Overhead Transmission Line

General Technical Specifications

High Voltage



Overhead Transmission Lines
General Technical Specifications– Overhead Transmission Line

TABLE OF CONTENTS

1. GENERAL REQUIREMENTS	7
1.1. GENERAL	7
1.2. SCOPE OF THE WORKS	7
1.3. SAFETY PROGRAM	7
1.4. QUALITY ASSURANCE PROGRAM	8
1.5. COOPERATION WITH OTHER CONTRACTORS	8
1.6. CONSTRUCTION AND STORAGE AREAS	8
1.7. RIGHT OF WAY AND ACCESS ROAD	9
1.8. PROTECTION OF REAL ESTATE CROSSED BY RIGHT OF WAY	9
1.9. SAFETY OF THE PUBLIC	9
1.10. COMMUNICATION AND POWER LINES	9
1.11. UTILITIES FOR CONSTRUCTION PURPOSES	10
2. DATA AND REFERENCE STANDARDS	10
2.1. GENERAL	10
2.2. DATA AND DRAWINGS FURNISHED BY THE EMPLOYER	10
2.3. STANDARD AND REFERENCES	10
3. DESIGN CONDITIONS AND CLIMATIC ASSUMPTIONS	11
3.1. SCOPE OF DESIGN WORK	11
3.2. CLIMATIC CONDITIONS	11
3.3. SPACING AND CLEARANCES	12
3.3.1. Electrical clearances	12
3.3.1.1. Clearance to ground and obstacles	12
3.3.1.2. Clearance between the conductors in midspan and still air	12
3.3.1.3. Clearance between conductors and earthwires	12
3.3.1.4. Clearance between towers lives and earthed parts:	13
3.3.2. Earthwire shade protection angle	13
3.4. LOADS AND LOADING CONDITIONS	13
3.4.1. Mechanical conditions	13
3.4.2. Breaking assumption for the Conductor and for the earth wire	13
3.4.3. Assumption for the construction and maintenance of the Works	14
3.4.4. Assumption for unhooking of one cable	14
3.4.5. Construction assumption	14
3.5. FOUNDATIONS	16
3.5.1. Soil Classification	16
3.5.2. Foundation Type	16
4. MATERIALS	17
4.1. GENERAL	17
4.2. LATTICE STEEL TOWERS	17
4.2.1. Tower Family	18
4.2.2. Tower Outline	18
4.2.3. Data and Drawings	20
4.2.3.1. Design Drawings	20
4.2.3.2. Detailed Drawings	20
4.2.4. Material for lattice towers	21



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

4.2.4.1.	Rolled shapes and plates	21
4.2.4.2.	Connection bolts, nuts and washers	21
4.2.4.3.	Bolt spacing	21
4.2.4.4.	Locking devices	21
4.2.4.5.	Tower signs	21
4.2.4.6.	Step Bolts	23
4.2.4.7.	Anti-climbing Devices	23
4.2.5.	Fabrication.....	23
4.2.5.1.	General	23
4.2.5.2.	Cutting.....	23
4.2.5.3.	Punching	23
4.2.5.4.	Bending	24
4.2.5.5.	Marking	24
4.2.5.6.	Cleaning and galvanizing.....	24
4.2.6.	Tower load test.....	25
4.2.6.1.	General	25
4.2.6.2.	Tower	26
4.2.6.3.	Erection	26
4.2.6.4.	Rigging	26
4.2.6.5.	Loading	26
4.2.6.6.	Loading program	26
4.2.6.7.	Deflection measurements	27
4.2.6.8.	Load tests.....	27
4.2.6.9.	Destruction test	27
4.2.6.10.	Modification of tower components	27
4.2.6.11.	Material tests	27
4.2.6.12.	Reports.....	28
4.2.7.	Packing and Shipping	28
4.2.8.	Bill of materials	28
4.3.	CABLES	28
4.3.1.	General	28
4.3.2.	Standards and regulations.....	29
4.3.2.1.	Basic standards	29
4.3.2.2.	Alternative standards.....	29
4.3.3.	Design and manufacture.....	29
4.3.3.1.	General	29
4.3.3.2.	Design data and performance.....	29
4.3.4.	Conductors	30
4.3.5.	Earthwire (OPGW) and telecom equipment	31
4.3.5.1.	General	31
4.3.5.2.	OPGW characteristics	31
4.3.6.	Tests	34
4.3.6.1.	General test requirements for conductor.....	34
4.3.6.2.	General test requirements for OPGW	34
4.3.6.3.	Tests after delivery	35
4.3.7.	Spare parts.....	35
4.3.8.	Packing, shipping, transport.....	35
4.4.	JOINTS AND FITTINGS	36
4.4.1.	General	36
4.4.2.	Insulators and insulator sets	39
4.4.2.1.	General	39



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

4.4.2.2.	Standards	39
4.4.2.3.	Design	39
4.4.2.4.	Requirements on Insulator Manufacturer	40
4.4.2.5.	Core	40
4.4.2.6.	Housing and Sheds	40
4.4.2.7.	Metal Fittings	41
4.4.3.	Clamps and fittings for conductors	41
4.4.3.1.	Suspension clamps	41
4.4.3.2.	Tension clamps, joints and repair sleeves for conductor	43
4.4.3.3.	Armor rods	43
4.4.3.4.	Guard rings	44
4.4.3.5.	Tests	44
4.4.4.	OPGW connection-to-tower sets	44
4.4.4.1.	General	44
4.4.4.2.	Suspension assemblies	45
4.4.4.3.	Tension assemblies	45
4.4.4.4.	Mid span joints for OPGW	46
4.4.4.5.	Tests	46
4.4.5.	Antivibration systems	46
4.4.6.	OPGW splicing	47
4.5.	AIRCRAFT WARNING SYSTEM	48
5.	WORKS	48
5.1.	GENERAL	49
5.2.	PRELIMINARY WORK	49
5.2.1.	Line Route Survey	49
5.2.2.	Towers Staking	50
5.2.3.	Line schedule check	50
5.2.4.	Line route pegs	50
5.2.5.	Tower relocation and route realignment	51
5.2.6.	Route modifications	51
5.2.7.	Vegetation clearing	51
5.2.7.1.	Easement clearing	51
5.2.7.2.	Danger tree clearing	51
5.2.7.3.	Re-clearing	51
5.2.8.	Wayleave	49
5.2.8.1.	General	52
5.2.8.2.	Damage to crops and property	52
5.2.8.3.	Protection of real estate and livestock	52
5.2.9.	Access	52
5.2.9.1.	General	52
5.2.9.2.	Existing access	53
5.3.	FOUNDATIONS	53
5.3.1.	General	53
5.3.2.	Design	54
5.3.2.1.	General	54
5.3.2.2.	Soil characteristics	55
5.3.2.3.	Calculations	55
5.3.2.4.	Caps	55
5.3.2.5.	Foundations stabilization	56
5.3.3.	Soil investigations	56
5.3.3.1.	General	56



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

5.3.3.2.	Quality assurance.....	56
5.3.3.3.	Investigations	57
5.3.3.4.	Reports.....	59
5.3.4.	Earth works	60
5.3.4.1.	General	60
5.3.4.2.	Fill materials	60
5.3.4.3.	Preparation of foundations.....	61
5.3.4.4.	Backfilling	61
5.3.4.5.	Blasting	61
5.3.4.6.	Protection of existing utilities and services.....	61
5.3.4.7.	Dust and mud control	62
5.3.4.8.	Draining during excavation	62
5.3.5.	Piling works (if necessary)	62
5.3.5.1.	Scope of work.....	62
5.3.5.2.	Documents to be submitted	62
5.3.5.3.	Pile prices.....	63
5.3.5.4.	Rejection	63
5.3.6.	Concrete works.....	63
5.3.6.1.	Materials for concrete	63
5.3.6.2.	Concrete mixes	64
5.3.6.3.	Testing of fresh concrete by means of test cubes	64
5.3.6.4.	Transport of concrete	64
5.3.6.5.	Concreting operations	64
5.3.6.6.	Formwork	65
5.3.6.7.	Reinforcing steel.....	65
5.3.7.	Foundation Orientation	66
5.3.8.	Grounding.....	66
5.3.8.1.	General	66
5.3.8.2.	Ground Connecting Wire	66
5.3.8.3.	Connections	66
5.3.8.4.	Marking	67
5.3.8.5.	Data and Drawing.....	67
5.3.9.	Protection against truck impacts	67
5.3.10.	Foundation tests	67
5.3.10.1.	Verification of stubs orientation.....	67
5.3.10.2.	Verification of foundations	67
5.3.10.3.	Pile Tests (if necessary)	67
5.4.	STEEL TOWER ERECTION	68
5.4.1.	Handling and storage	68
5.4.2.	Tower erection.....	68
5.4.2.1.	Erection procedures	68
5.4.2.2.	Bolt tightening.....	69
5.4.2.3.	Faulty members.....	69
5.4.2.4.	Damaged members	69
5.4.3.	Damaged Galvanizing	70
5.4.4.	Tower Signs	70
5.4.5.	Painting of the top Part of Towers.....	70
5.4.5.1.	Inspection and warranty.....	70
5.4.5.2.	Weather conditions.....	70
5.4.5.3.	Surface preparation	71
5.4.5.4.	Preparation of coating materials	71



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

5.4.5.5.	Application.....	71
5.4.5.6.	Red/white tower painting	72
5.5.	INSTALLATION OF CONDUCTOR AND OPGW	72
5.5.1.	Generality on conductors and OPGW stringing.....	72
5.5.1.1.	Handling and storage	72
5.5.1.2.	Stringing plan	72
5.5.1.3.	Crossing of roads, power lines etc.	72
5.5.1.4.	Tools and equipment	73
5.5.2.	Line hardware and insulator assembly installation	74
5.5.3.	Stringing OPGW	74
5.5.4.	Stringing conductors.....	75
5.5.5.	Earthing of conductors, OPGW and stringing equipment	76
5.5.6.	Repair of damaged conductors and OPGW	76
5.5.7.	Jointing of conductors and OPGW	76
5.5.8.	Sagging	77
5.5.9.	Clipping in.....	78
5.5.10.	Vibration Protection Devices	78
5.6.	CLEAN-UP	78
6.	LINE TESTING	79
6.1.	FINAL CHECKING AND TESTING	79
6.1.1.	Final checking	79
6.1.2.	Line testing	79
6.2.	HAND-OVER DATE.....	79



1. General Requirements

1.1. General

The Contractor shall assume full responsibility for the adequacy and accuracy of the Work which is required to be provided.

The Contractor shall be deemed to have carefully examined the Bid Documents and all conditions affecting the execution of the Work and to have formulated an estimate of facilities available and needed.

All materials, designs, details, fabrication and tests shall be in compliance with details on the drawings and the requirements described hereafter.

All designs and details shall be subject to the reviewing by the Engineer. The Engineer reserves the right to have the Contractor, without additional cost, make any necessary changes in designs and details to make the construction conform to these Technical Specifications.

No omission or ambiguity on the drawings or in these specifications will relieve the Contractor from the responsibility for furnishing first class materials and workmanship. Should any inaccuracy be found, any further work done before such inaccuracy is corrected will be at the Contractor's risk and expenses.

1.2. Scope of the Works

The General Technical Specifications are related to the construction of 220kV 66kV overhead lines.

The works shall be based on the line route as per provided drawings before the execution phase.

The Work comprises design, manufacture, factory test, delivery at site, erection, field test, commissioning and maintenance during the product liability period for the supply of steel towers (including the stubs of towers), conductors, OPGW, insulators, hardware and accessories and all works related to transportation and erection.

The scope includes also the detailed design studies of civil works, specially the determination of tower foundation type (pile or footing), the earthing calculation note, the calculation of reinforcement bars, drawings, bending schedule and bill of quantities.

The type of foundation shall be approved by the Employer before starting the detailed studies.

All components and accessories necessary for safe and efficient operation at site in accordance with sound engineering practice shall be included in the supply.

The inclusive limits of supply for equipment are defined in the Particular Technical Specifications.

The payment of supply and installation of cables (conductors and OPGW) shall be based on section lengths only and not on cable lengths.

1.3. Safety program

The Contractor shall ensure that safe work practices are developed and adopted by all personnel. Such safe working practices shall be developed without limitation in respect of safety equipment, workers equipments, barriers and signals for dangerous areas, noise protection, lighting, equipment management, order and tidiness, signs, house-keeping,



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

heating and/or cooling devices, paint and painting, emergency procedures, instructions, electrical activities, working at heights, safe transport and lifting, forklift trucks, hoisting, welding/burning, storage and handling of gas, work inside confined spaces, underground works, dangerous/flammable products, hand tools, storage and handling of radio-elements, work permits, explosives, rock drillings, rock bolting, concrete placement, crane operations, earth moving and excavation plant and equipment, vehicle driving.

Prior to starting construction and installation, the Contractor shall submit six copies of Safety Program to the Employer for reviewing.

Safety Program shall include, as a minimum, a safety manual, a program of safety meetings and the designation of a safety supervisor(s).

The Contractor's safety manual should include a statement of safety policy and objectives and basic elements of safety. Also inclusion should be guidelines for personal safety, protection of the public, accident prevention, house keeping at the sites, first aid, maintenance and repair of tools and equipment and precautions to be observed.

The program of safety meetings shall be carried out through the time of construction and installation. The name and qualifications of the designated safety supervisor shall be stated.

1.4. Quality assurance program

The Contractor shall submit six copies of Quality Assurance Program for the reviewing of the Employer.

Quality Assurance Program shall include a description of the organization of the Contractor's quality assurance team and program, his control and checking procedures for surveys, subsoil investigations, construction drawings and incidental design; document control and contract administration. For procured equipment, the program for controlling quality through process control, inspections, test control and the procedures for correcting possible production of non-conforming articles shall be included. For construction and installation, the Contractor shall propose procedures for controlling the quality of foundations, tower erection, stringing, splicing and testing. For the overall project, the Contractor shall describe his planned reports and quality assurance records.

1.5. Cooperation with other contractors

The Contractor shall cooperate with any other Contractors for and workmen of the Employer who may be performing work at or near the Work hereby contracted and shall conduct the operations so as to interfere to the least possible extent with the work of such other Contractors, or workmen. Any discrepancies or conflict which may arise between the Contractor and other such Contractors or workmen will be adjusted and determined by the Employer. If the Work of the Contractor is delayed, as determined by the Employer, because of any acts or omissions of such other Contractors or workmen, the Contractor shall have no claim against the Employer on that account other than an extension of time.

1.6. Construction and storage areas

The Contractor shall be responsible for providing his own construction and storage facilities. The location of all construction and storage areas is subject to the acceptance of the Engineer.

The Contractor shall be responsible for the security and protection of all Equipment within the construction and storage areas. Necessary fence, roof, platform or other means shall be provided for protection of the equipment from loss or damage caused by water, fire,



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

accident... The construction and maintenance of such storage areas shall be subject to the acceptance, inspection and direction of the Engineer. All costs for such protection of the Equipment shall be borne by the Contractor.

1.7. Right of way and access road

The Contractor shall be responsible for the realization of all access to work. The Employer assumes no responsibility for the condition or maintenance of any proposed access routes, or of any existing roads or structure thereon that may be used by the Contractor for performance of the Work. Any and all work required along the routes to provide suitable access shall be performed by the Contractor at his expenses.

The Contractor shall construct roadways they are necessary for the movement of the Contractor's equipment.

1.8. Protection of real estate crossed by right of way

The Contractor shall limit the movement of his crews and equipment so as to minimize damage to crops and property and shall endeavor to avoid marring the lands. Ruts and scars shall be obliterated; damage to ditches, tile drains, terraces, roads and other features of the land shall be corrected. The land shall be restored as nearly as practicable to its original condition before final acceptance of the Work.

All expenses incurred in the performance of any work described in this Clause shall be borne by the Contractor.

1.9. Safety of the public

The Contractor shall provide, erect and maintain all necessary barricades, suitable and sufficient red lights, danger signals and signs and take all necessary precautions for the protection of the Work and safety of the public. Roads closed to traffic shall be protected by effective barricades on which shall be placed acceptable warning and detour signs. All barricades and obstructions shall be illuminated at night and all lights shall be kept burning from one hour before sunset until one hour after sunrise. The costs of all work required by this Clause shall be borne by the Contractor.

1.10. Communication and power lines

The Contractor shall conduct his operations so as not to close or obstruct any portion of any road, alley or pipeline until he has obtained permits from the appropriate authorities.

The Contractor shall use all necessary and practical precautionary measures to prevent service interruption on all roads, communication and power lines existing on the date of bid opening to be crossed by the transmission line during construction. The Contractor shall obtain all required permits and shall notify the proper authorities not less than one month before beginning the work at any such crossings. The Contractor shall execute the work in a manner that is mutually agreeable to all parties involved and shall provide all necessary equipment and personnel to accomplish the crossings in the agreed manner.

The Contractor shall notify the Employers of such facilities of any damage which is his responsibility and shall promptly settle proper claims. Pending settlement of such claims by the Contractor, an appropriate sum as determined by the Employer may be withheld from payments due to the Contractor until the matter is settled.



1.11. Utilities for construction purposes

The Contractor shall make all necessary arrangements and shall provide all necessary electric power, water, etc. for construction purposes. The cost of such utilities shall be borne by the Contractor.

2. Data and reference standards

2.1. General

The drawings and data to be provided in these Bid Documents present the work to be performed under this order in as complete detail as possible at the present stage of work. These drawings and data shall not be used for construction and installation of the work.

2.2. Data and drawings furnished by the employer

The Contractor shall assume full responsibilities to verify the plan profile drawings furnished by the Employer. The Contractor shall provide AutoCAD plan profile drawings showing tower locations and tower types to be employed including diagonal profile and plan drawings for hill side towers, if required. These drawings and documents shall be submitted to the Employer for reviewing with survey data.

2.3. Standard and references

All equipment, materials, fabrication and tests under these Specifications shall conform to the latest applicable standards, manuals and specifications contained in the following list or to equivalent applicable standards, manuals and specifications established and approved in the country of manufacture and accepted as equivalent by the Engineer.

- ACI American Concrete Institute
- AFNOR French Standards
- ASTM American Society for Testing Materials
- IEC International Electromechanical Commission
- ISO International Standards Organization

Any details not specifically covered by these Standards and Specifications shall be subject to acceptance of the Engineer. In the event of contradictory requirements between the standards and these specification requirements, the terms of the Specifications shall be applicable.

In some places, reference is made to certain manufacturers' products, brand-name materials and items identified by registered trade-marks. This has been done to define and establish standard of quality and/or performance and is not intended to restrict the procurement of materials or equipment to a particular manufacturer.

Any reference made to standards and specifications, or to equipment and materials of a particular manufacture shall be identified as "or equivalent". The Contractor may propose equivalent standards, specifications, materials or equipment which shall be equal in every respect to that specified. If the Contractor, for any reason, proposes any equipment equivalent to, or deviated from, the above standards, the Contractor shall state the exact nature of the change and the reason for making the change and shall submit complete



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

specifications of the materials, as well as copies of pertinent standards, for the acceptance of the Engineer and the decision of the Engineer regarding the matter of quality will be final.

The Contractor shall submit to the Engineer within one month after the beginning of the project all relevant codes and standards he intends to apply on the project in accordance with the Technical Specifications.

When a Standard mentions that a test is optional, it should be considered by the Contractor that this test shall be performed unless he receives clear agreement from the Engineer.

3. Design conditions and climatic assumptions

3.1. Scope of design work

All designs and details shall be subject to reviewing by the Contractor. The Employer reserves the right to have the Contractor, making any necessary changes in designs and details to make the construction conform to the Contract Documents.

No omission or ambiguity on the drawings or in these specifications will relieve the Contractor from the responsibility for furnishing first class materials and workmanship. Should any inaccuracy be found, any further work done before such inaccuracy is corrected will be at the Contractor's risk.

The Contractor has to use the three-dimensional indeterminate stiffness method of checking for tower design. The computer program to be used shall be developed or tested by a recognized institute such as PLSCADD/TOWER from Power line Systems Inc and acceptable to the Engineer.

However, the Contractor may use another recognized design method proved to be accurate.

3.2. Climatic Conditions

CASE number	ASSUMPTIONS	Temp °C	WIND ON TOWER Pascal	WIND ON CONDUCTORS Pascal
1	Repartition	65	0	0
2	Cold	0	300	180
3	Everyday	20	0	0
4	Normal Wind	20	1200	480
5	Full Wind	20	1330	640
6	Light Wind	20	-	240



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

3.3. Spacing and clearances

3.3.1. Electrical clearances

The positioning of the conductors and of the earthwires on the tower shall be determined considering the following clearances:

- The clearance to ground and obstacles
- The clearances between the conductors in midspan and still air
- The clearances between tower's live and earthed parts
- The clearances between conductors and structures.

3.3.1.1. Clearance to ground and obstacles

The vertical conductor clearances to other features based on final conductor sag at 65°C.

The minimum vertical clearances of conductors at a maximum conductor temperature in still air shall be as listed below:

The following are the minimum clearances between line conductors and other objects, to correspond with the maximum conductor sag conditions.

Item	Description	Minimum clearance
1	Normal ground	16 m
2	Roads and streets	16 m
3	Buildings	5 m
4	Vegetation	5 m
5	Telecommunication and power lines	3 m

0.5 m shall be added to the clearance values above to allow for survey and drawing errors.

The Contractor shall indicate the total creep which he will consider after ten years operation and shall base his bid on the assumption that this creep will be compensated by stringing the conductor correspondingly at initial sags.

3.3.1.2. Clearance between the conductors in midspan and still air

This condition must be verified with the "Light Wind" Condition at final conductor sag at 20°C

$$c > 0.35 \text{ m}$$

The Contractor shall take into account the oscillation of the conductors. The verification method shall receive the Engineer agreement.

3.3.1.3. Clearance between conductors and earthwires

This condition must be verified with the "Light Wind" Condition at final conductor sag at 20°C

$$c > 0.2 \text{ m}$$

The Contractor shall take into account the oscillation of the conductors. The verification method shall receive the Engineer agreement.



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

3.3.1.4. Clearance between towers lives and earthed parts:

The clearances between live and earthed parts have to be considered as follows:

- For suspension towers, the following electrical clearances have to be observed, as a function of the insulator set swing angle under wind as follows:

Everyday climatic condition (n°3)	1 m
Light wind climatic condition (n°6)	0.7 m
Full wind climatic condition (n°5)	0.15 m

- For angle tension towers, as a function of the jumper loop swing angle under wind:

Everyday climatic condition (n°3)	1 m
Light wind climatic condition (n°6)	0.7 m

The electrical clearances specified are to be considered as minimum dimensions to be provided between the outermost tower steel parts (outstanding web angles, step bolts) to the nearest point of the line conductor, insulator set live hardware or conductor accessory.

3.3.2. Earthwire shade protection angle

A shade protection angle of the earth wires equal to 30° maximum to the vertical of the upper phase conductors shall be considered.

The catenaries of the earthwire shall be at 20°C, 15% superior to the catenaries of conductor for the basic spans of 400m.

3.4. Loads and loading conditions

3.4.1. Mechanical conditions

(Refer to Table n°1)

The weather conditions that shall be taken into consideration for the calculation of the mechanical resistance of the Works are the least favorable ones that can be met on the Works.

3.4.2. Breaking assumption for the Conductor and for the earth wire

This assumption describes for all the metallic towers a minimal resistance to the necessary torsion to resist the break-up of one phase (conductor), of the earth wire or the midspan joint.

For the towers equipped with suspension sets, the longitudinal force due to the break-up of one phase is determined taking into consideration the loosening resulting from the gradient of the set. The discharge coefficient that will be considered will be equal to 0.6 (the maximum value of this force is however limited to 3 000 daN per cable).



3.4.3. Assumption for the construction and maintenance of the Works

During the construction and maintenance works, the towers should bear the exceptional strengths that may be applied and that will vary depending on the operational methods used. It is necessary to define, with appropriate assumptions, the strengths that shall be taken into consideration during the conception of a tower. The operational methods that will be considered on site should also be conceived in a way that these strengths are not over passed.

The assumptions for the construction and maintenance of the Works are to be verified for each type of tower.

3.4.4. Assumption for unhooking of one cable

The weather conditions are the normal conditions of work:

- Temperature +20°C
- Absence of wind

The loading applied on the towers are the following:

- Unbalanced loads on a suspension tower (or unhooking of one or more conductors)
- One phase of the conductors is not implemented or is unhooked. This application is done at each point of hooking, the least favorable case is considered.
- Earth wire (if it exists) is not installed or is hooked-up.

The conditions to respect are the unbalanced loads.

The maximal stress acceptable in the structural metallic elements of the towers – taking into account the buckling if it exists – should be less than the minimal elastic stress limit divided by 1.8.

3.4.5. Construction assumption

A vertical force of 200 daN corresponding to the weight of two workers and their tools is applied at the middle of all the bars, other than the main legs. These forces will be added to the normal stresses that are withstood by the tower at everyday assumption.

The maximal stress acceptable in the bars, other than the main legs is equal to the minimal value of the minimal elastic stress limit divided by 1.2.

Overhead Transmission Lines
General Technical Specifications– Overhead Transmission Line

Table 1

LOAD CASE	ASSUMPTIONS	Temp °C	WIND ON TOWER Pascal	WIND ON CONDUCTORS Pascal	Conditions and factor of safety						
					Cables	hardware	Tower	<u>Foundation</u>			
								<30gr		>30gr	
								comp	uplift	comp	uplift
1	Repartition	65	0	0							
2	Cold	0	300	180	0.95*BL/3	R/3	MES/1,8	1	1.5	1	1.8
3	Normal Wind	20	1200	480	0.95*BL/3	R/3	MES/1,8	1	1.5	1	1.8
4	Full Wind	20	1330	640							
5	Normal Wind one broken wire	20	1200	480	0.95*BL/3	R/3	MES	1	1.5	1	1.8
6	oblique wind 45°	20	940	450	0.95*BL/3	R/3	MES/1,8	1	1,5	1	1,8
7	no wind stringing & maintenance	20	0	0	0.95*BL/3	R/3	MES/1,8	1	1	1	1

R: Breaking force or stress

MES: guaranteed minimal elastic stress.

BL: Breaking Load



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

3.5. Foundations

The Contractor is required to design, for each tower type, suitable foundations for each kind of soil classified hereunder.

The responsibility for proving the adequacy of the foundation type at each location shall remain to the Contractor according to the results of soil investigation performed by the Contractor and reviewed by the Engineer.

3.5.1. Soil Classification

The soil has been classified into six classes as follows:

Soil Class	Description	Density kg/m ³	Angle of Repose	Ultimate Bearing Capacity MPa
I	Very Soft	900	0	<0.1
II	Soft	1,000	5	0.15
III	Fair	1,200	15	0.3
IV	Good	1,700	20	0.5
V	Hard	2000	30	0.75

Soil class I, II and III are submerged. Disintegrated rock shall be classified as soil class V.

3.5.2. Foundation Type

Foundation type for each soil class shall be as follows:

Soil Class	Foundation Type
I II III, IV, V	Long Pile Short Pile or pad Pad

Foundation design shall be such that the tower shall be securely supported and unbalanced displacement that may cause harmful effect to the tower shall not be produced.

The loads acting on the foundation shall be the maximum loads determined from each tower loading condition and shall take the leg extension of tower into account.

Stability of foundation shall conform to the requirements of table 1.

Foundation design loads shall be calculated on the basis of the maximum axial and horizontal tower base reactions exclusive of tower overload factor and further multiplied by the factors specified above. Maximum foundation shear force from any load combination for the download leg will be assumed to act simultaneously with the maximum foundation compression force. Maximum foundation shear force from any load combination for the uplift leg will be assumed to act simultaneously. Undercuts shall be used as much as possible (for fair and good soils).



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

All combinations of tower and leg extension heights, as stated in the tower design specification, shall be considered in determining the maximum tower base reactions.

Any information given in the Technical Specification in relation to the foundation design is for tendering purpose only. For the final foundation design the Contractor has to perform the required soil investigations and has to base his design calculations on the detailed information obtained. The Contractor is requested to quote firm unit rates for the different types of foundations and towers as set out in the Price Schedules. These unit rates will be considered as flat rates covering all foundation costs for any type of soil encountered along the line and no adjustment of the rates will be permitted.

4. Materials

4.1. General

The Contractor shall assume full responsibility for the adequacy and accuracy of the portion of the work which is required to be provided.

All materials, designs, details, manufacturing, fabrications and tests shall be in compliance with details on the drawings and the requirements described hereafter.

All materials shall be brand-new and manufactured for this Project. Any steel member with trace of hole filling shall not be used.

No omission or ambiguity on the drawings or in these specifications will relieve the Contractor from the responsibility for furnishing first class materials and workmanship. IF any inaccuracy is found, any further work done before such inaccuracy shall be corrected at Contractor's risk.

4.2. Lattice Steel towers

All materials shall be brand-new and of the best quality for use in the conditions and the variations in temperature and pressure that will be encountered in service without undue distortion or deterioration or the setting up of undue strains in any part that might affect the efficiency and reliability of the plant.

Special attention must be paid to eliminating the possibility of corrosion resulting from galvanic effects. Design, selection of materials and all methods of erection shall be such as to keep these effects to a minimum.

Materials complying with codes and standards listed below shall be used for the design and construction work.



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

4.2.1. Tower Family

Tower family to be designed, supplied and erected shall be as follows:

Tower Type	Application	Line Angle (Grades)	Wind Span (m)	Min Weight Span (m)	Max Weight Span (m)
A	Suspension Light	0	400	-150	600
B	Suspension Heavy	0	400	0	900
C	Tension	30-45	400	0	900
D	Dead End and T_Off Tower	0-20	200	-100	500

4.2.2. Tower Outline

The outlines of the towers shall, in general, conform to those indicated on the drawings and shall be such as to provide the required minimum clearance between conductors and between conductors and tower steel, indicated in the clearance diagrams.

Towers shall be designed for leg extensions of heights indicated on the drawings and for use with any combination thereof (-3 m to + 3 m). The effect of maximum height differential of leg extension combination shall be taken into account.

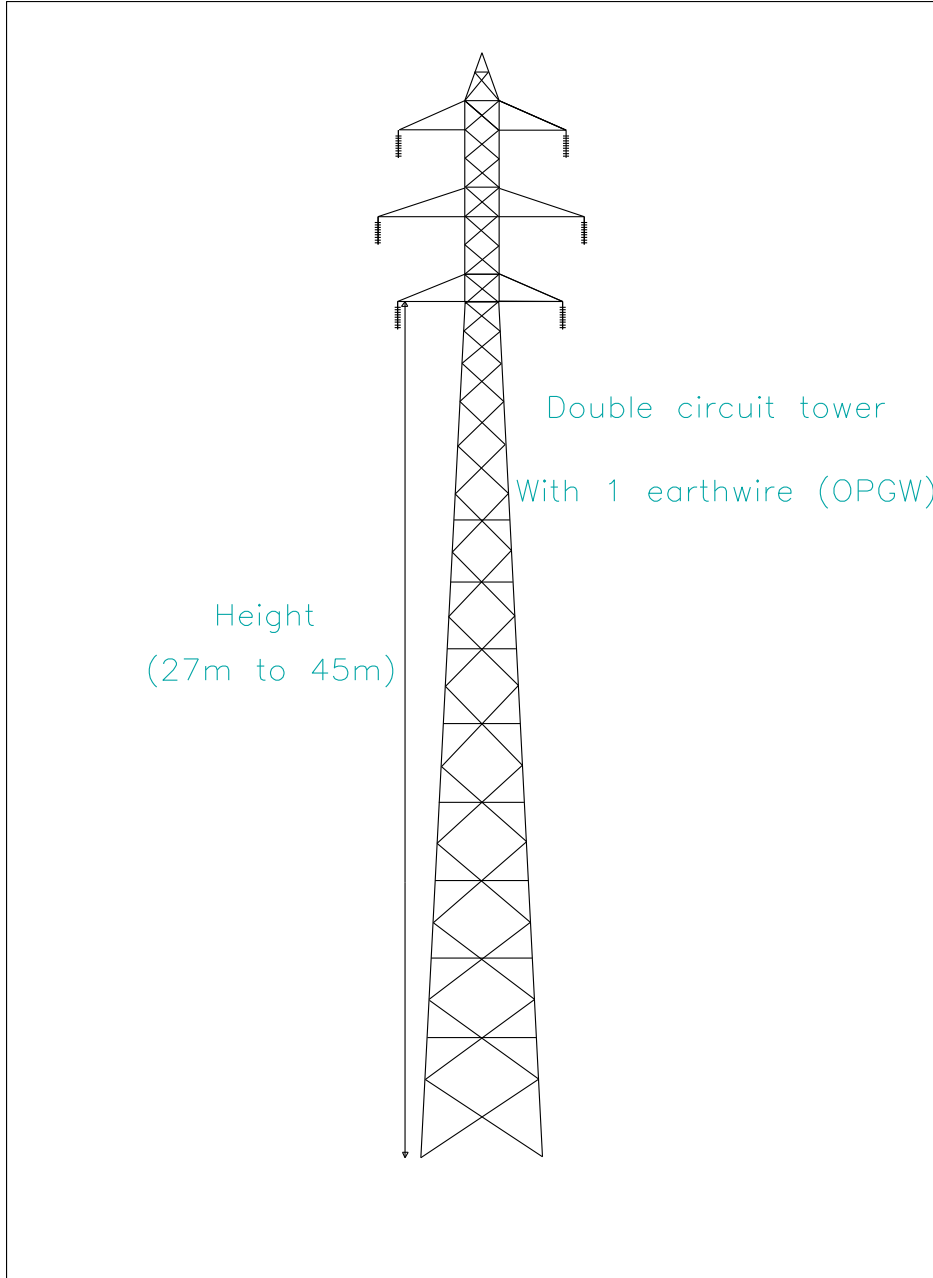
Plan bracing of towers at the levels of crossarms shall be such a type to prevent the cross section of the towers from deforming from the original form under torsional loading.

The included angle between any two connecting stressed members shall not be less than 15 degrees. The dimensions of the tower bases shall be such as to give the most economical structures, considering foundations and right-of-way conditions.



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line



4.2.3. Data and Drawings

4.2.3.1. Design Drawings.

The design drawings shall show the following data and information.

Scaled line diagram of the tower showing all redundant, bracing members and their sizes completely dimensioned and proved in compliance with all clearance requirements.

All loadings and their manners of application including the determination of wind load on tower. Wind load on towers shall be applied at each panel point along the height of the towers.

Tables showing:

- Total stresses in each member for each loading case and the critical case.
- The effective slenderness ratio, calculated capacity and ratio of maximum total stress to calculated capacity for each member and connection.
- Size and type of steel for each member and number of bolts required for its connection.
- The compression and uplift reactions and corresponding horizontal shears at each leg of all towers for all loading cases.

4.2.3.2. Detailed Drawings

Detailed drawings shall be complete with sizes and detailed dimensions of all members. At each joint, there shall be the number, size and length of bolts, number and size of fillers and detailed dimensions of gusset plate, if any.

All members and plates shall be designated on drawings, the Contractor shall endeavor to use as few designation as possible and each member of identical size and detail shall have the same designation, regardless of its position in the structure.

The member and plate designation shall be successively grouped on individual drawing. The groups of designation shall be indicated on the drawings.

A proper cross-index shall be furnished, correlating the tower part numbers with the tower types and the drawing number.

Drawings shall include material list which shall give the size, length and galvanized weight of each member and the total weights of body, body extension, leg extension and stub conforming to detailed drawing. It shall also include the number of bolts, nuts, washers and cable attachment devices per tower.

Leg extensions /reductions in step of 1 meter shall be provided for each body extension preferably interchangeable within one tower type (from -3 meters to +3 meters).



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

4.2.4. Material for lattice towers

4.2.4.1. Rolled shapes and plates

All materials shall be hot-rolled of mild steel and /or high-strength steel and shall conform to the steel qualities according to EN-10025 (European Norms) or equivalent standards.

The chemical composition and mechanical properties of the grades of steel used shall correspond to EN to be suitable for working in the project area.

High-strength grade bars shall clearly be identified.

4.2.4.2. Connection bolts, nuts and washers

All connections shall be bolted. Bolts shall bear on the shank to the extent that not more than one full thread shall be in bearing. Rivets or welding shall not be used.

For structural connections, one bolt size is preferred.

The quality of bolts shall be not less than 5.8 according to ISO 898 or equivalent. Metric threaded bolts shall be used.

All nuts and bolts shall be hot dip galvanized; threads before galvanizing shall be coarse threads. There shall be no excess of galvanizing at the root of the thread and nuts shall turn easily on the complete bolts without excessive looseness.

Bolts will be rejected if they are considered by the Engineer to have an excessive loose or tight fit.

4.2.4.3. Bolt spacing

Bolt spacing and edge distance, in mm, shall be as follows:

Nominal Bolt Diameter	Bolt Spacing		Minimum Edge Distance	
	Min.	Max.	Rolled Edge	Sheared Edge
12	30	120	16	20
16	40	160	22	25
20	50	200	27	30
24	60	240	32	40

4.2.4.4. Locking devices

All tower bolt connections shall be with one flat washer and one spring washer. The bolts shall be pointed by two marks.

4.2.4.5. Tower signs

Signs, consisting of aerial patrol signs, phasing signs, circuit name signs, danger signs and number signs shall be made of aluminum or mild steel covered with enamel on both sides.



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

Tower signs shall be mild steel. The thickness shall not be less than 2 mm.

The Contractor shall furnish all materials for tower signs, including all bolts, nuts, washers, brass eyelets fitted with the holes and supporting structures, if required, for attaching tower signs to the towers as specified in the structure list.

The colors of figure and background shall be weather-proof, baked enamel finish paint, vitreous or stove enamel. The paint or using prominent letters and numbers shall be brand-new and of the best quality for use in the conditions and the variations in temperature and pressure that will be encountered in service without undue distortion or deterioration or the setting up of undue strains in any part that might affect the efficiency and reliability of the plant.

The Contractor is required to make provision in the tower members for attaching signs at the locations described hereunder.

a) Airborne plates

Tower airborne plates (2 Nos.) shall show the tower number in black letters, on a white background. The figures height shall be 350mm.

Airborne plates shall be attached to upper part of the tower body and shall be provided at every tower.

b) Designation plates

Tower designation plates (2 Nos.) shall show the abbreviated OHTL's name in black letters, on a white background. The figures height shall be 50mm.

Designation plates shall be attached about three meters from ground level and above anti-climbing guards and shall be provided at every tower.

c) Phase plates

Phase plates shall show the English letters "R", "S" and "T", in black color, on red, resp. yellow, resp. blue background.

Two sets of three phase plates shall be attached about three meters from ground level and above the anti-climbing guards and be provided at angle and dead end towers.

d) Danger plates

Danger plates (2 Nos.) shall feature red symbols on a white background. They shall comprise a skull with crossed bones, as well as lightning arrows conforming to DIN 40006. The text "DANGER" shall be boldly written in both, Arabic and English languages. The voltage shall be shown, as well.

Danger plates shall be attached about three meters from ground level and above anti-climbing guards and be provided at every tower.

e) Number plates

Tower number plates (2 Nos.) shall show the tower number in black letters, on a white background. The figures height shall be 50mm.

Number plates shall be attached about three meters from ground level and above anti climbing guards and be provided at every tower.

The Contractor shall submit to the Engineer for approval the different drawings for Tower signs with clear information.



4.2.4.6. Step Bolts

The minimum diameter of step bolt shall be of 16 mm and shall have round or hexagonal head. Each step bolt shall be provided with two hexagonal nuts. The minimum bolt length and length of unthreaded portion shall be 180 and 125 mm respectively.

Step bolts shall not be used as connection bolts.

The step bolts shall be spaced alternatively on the inner gauge line on each face of the angle about 40 cm on centers.

4.2.4.7. Anti-climbing Devices

Each tower shall be fitted with an anti-climbing device to prevent unauthorized persons from climbing the tower. The anti-climbing device shall be fixed at a height of approximately 3 meters above the foundation. It shall provide suitable lockable gates adjacent to the step bolt legs.

4.2.5. Fabrication

4.2.5.1. General

Workmanship for fabrication shall be first class throughout. All pieces must be straight, true to detailed drawings and free from lamination flaws and other defects. All clipping, back-cuts, grindings, bends, holes and etc. must be true to detailed drawings and free of burrs.

All identical pieces bearing the same erection number must be exactly interchangeable with each other and interchangeable in their relative position in all towers of structures or which they form a part.

Threads of bolts and nuts shall be cleanly rolled or cut and the face and head of nut shall be truly at right angle to the axis of the bolt.

4.2.5.2. Cutting

Members shall be cut or sheared to length. The ends, unless as shown on the drawings, must be square with the length. The use of burning torch is not permitted for cutting.

4.2.5.3. Punching

The diameter of bolt hole shall not exceed 1.5 mm plus the bolt diameter.

Holes are to be punched with racks and jigs employed to ensure accuracy throughout. The punches and dies for this work must be maintained sufficiently sharp so as to produce clean round holes normal to the plane of material, free of burrs, folds, depressed or upset edges.

Holes in bent members which may be affected by the bending operation shall be laid out and punched or drilled after bending. Holes which are elongated or otherwise distorted by bending will not be accepted.

Mis-drilled or mis-punched hole shall not be refilled. Member of such hole shall be discarded.



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

4.2.5.4. Bending

All bending of high strength structural steel must be done hot. Bends of a difficult nature on structural steel must be done hot, but otherwise cold bending can be employed.

4.2.5.5. Marking

All individual pieces shall be marked with the correct designations shown on the detailed drawings. Markings shall be done by stamping the marks into the metal before galvanizing and details shall be clearly legible after galvanizing. The number and letter shall be a minimum of 12 mm in height.

Marking of bolts shall be made on bolt heads to identify manufacturer, grade, size, length and threaded length. Markings may be raised or depressed.

4.2.5.6. Cleaning and galvanizing

4.2.5.6.1. Cleaning

After fabrication has been completed and accepted, all materials shall be clear of rust, loose scale, dirt, oil, grease and other foreign substances that may affect the uniformity of the coating.

4.2.5.6.2. Galvanizing

All steelwork shall be hot dip galvanized in accordance with internationally recognized standards such as EN ISO 1461 providing a smooth, clean and uniform zinc coating of min 700 g/m² (100 micrometers) thickness for bars and plates and 500 g/m² (70 micrometers) for bolts, including the threaded portion. All nuts shall be equally hot dip galvanized. The threaded portion will be greased.

Nuts and locknuts shall be galvanized after threading. Retapping of nuts and locknuts after galvanizing, if required to ensure free running of nut on bolt, shall be such that sufficient protective zinc or tapping oil will remain on threads in nuts and locknuts.

Finished materials shall be dipped into a solution of dichromate or be otherwise treated after galvanizing for white rust protection during sea transportation and storage.

Vent-holes and drain-holes should be provided to avoid high internal pressures and air-locks during immersion, which may cause explosions and to ensure that molten zinc is not retained in pockets during withdrawal.

All defects of the steel surface including cracks, surface laminations, laps and folds shall be removed. All drilling, cutting, welding, forming and final fabrication of unit members and assemblies shall be completed before the structures are galvanized. The surface of the steelworks to be galvanized shall be free from paint, oil, grease and similar contaminants.

On removal from the galvanizing bath, the resultant coating shall be smooth, continuous, free from gross surface imperfections such as bare spots, lumps, blisters and inclusions of flux, ash or dross.

Galvanized contact surfaces to be joined by high-tensile friction grip bolts shall be roughened before assembly so that the required slip factor is achieved. Care shall be taken to ensure that the roughening is confined to the area of the mating faces.

Bolts, nuts and washers, including general grade high-tensile friction grip bolts shall be hot-dip galvanized and subsequently centrifuged. Nuts shall be tapped up to 0.4 mm oversize after galvanizing and the threads oiled to permit the nuts to be finger-turned on the bolt for the full



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

depth of the nut. No lubricant, applied to the projecting threads of a galvanized high tensile friction-grip bolt after the bolt has been inserted through the steelworks, must be allowed to come into contact with the mating faces of the steelworks.

Small areas of the galvanized coating damaged in any way shall be restored by:

- Cleaning the area of any weld slag and thorough wire brushing to give a metallic clean surface.
- The application of two coats of zinc powder-rich paint, or the application of a low melting point zinc alloy repair rod or powder to the damaged area, which is heated to 3000°C.

4.2.5.6.3. Minor repair

Materials on which galvanizing has been damaged shall be re-dipped unless in the opinion of the Engineer, the damage is local and can be repaired by applying a coating of galvanizing repair paint.

Where such repair is authorized, the damaged area shall be cleaned by wiping with clean rags saturated with mineral spirits of xylene, followed by wire brushing. After wire brushing, the area shall be re-cleaned with solvent to remove residue and shall be given one heavy brush coat of galvanizing repair paint. The percentage of pure zinc by weight in dry film of galvanizing repair paint shall not be less than 85.

4.2.6. Tower load test

4.2.6.1. General

- The suspension towers shall be tested at the “Destruction test” as following described;
- The tension towers shall be tested at the “Load test” as following described.

The test loads shall be the design loads multiplied by the corresponding safety factors.

The Contractor shall give the Engineer notification in writing, not less than 30 days in advance, of the date when towers will be ready for test.

The test shall be performed with the Engineer in attendance and in accordance to IEC Publication 60652 "Loading tests on overhead towers".

The Contractor shall supply a detailed Quality Assurance Procedure and shall be responsible for performing all tests and inspections required during the production of the towers.

The Contractor shall identify all materials, including bolts and nuts used in the project on the appropriate mill test reports and/or material certificates and shall furnish the mill test reports and/or certificates to the Employer.

The Contractor shall make dimensional checks of all materials for conformity to the relevant material standard. The Contractor shall make a visual inspection of all materials before and after galvanizing. Size of test "lot" and number of tests shall be in accordance with appropriate standards.

In addition to the above inspection and tests, the Contractor is required to perform the following tests at his own expense on samples selected at random by and in the presence of the Engineer or of his representatives.

- Physical tests on samples of structural steel sections



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

The tests to be carried out shall include yield strength, ultimate tensile strength and percentage elongation. One set of tests shall be carried out for each 50 tons of steel passing through the fabrication plant.

- Galvanizing tests on samples of structural steel sections
The tests to be carried out shall include determination of weight of zinc coating, adherence of zinc coating and uniformity of zinc coating. One set of tests shall be carried out for each 50 tons of steel passing through the fabrication plant.
- Mechanical and galvanizing tests on bolts and nuts
Mechanical property and galvanizing tests on samples of bolts and nuts shall be carried out in accordance with the requirements.

4.2.6.2. Tower

The tower shall be fabricated according to the detailed drawings approved in a manner as close to final production procedures as practicable. The tower shall be complete in every detail. Markings for test tower members shall be prefixed with the letter "T".

4.2.6.3. Erection

The tower shall be erected on a rigid foundation using the specified tower bolts and nuts tightened to the specified torque.

4.2.6.4. Rigging

The Contractor shall submit for approval diagrams showing the proposed methods of applying loads and deflection measuring.

4.2.6.5. Loading

Test loads shall be the design working loads multiplied by corresponding safety factors. All test loads corresponding to conductor and earth wire loading shall be applied directly to the regular attachment details provided for those loads. Test wind loads equivalent to wind loads on the tower shall be applied where convenient and in such a manner that the locations and the summations of applied load and overturning moment are as close as possible to the actual conditions, as designed.

An extra compressible member is not allowed for use in applying wind loads on tower. To ensure application of full-test loads to the tower, friction losses in rigging shall be computed and added to the rigging loads.

The first load case in a Heavy Angle tower testing program should be the one that produces the largest leg force. If subsequent load cases also give sufficiently high leg force, tower bolts at major joints must be loosened and re-tightened prior to the test to minimize residual loads.

4.2.6.6. Loading program

The Contractor shall program the tests to most favorably demonstrate that the towers will carry all design loads and conditions specified in the loading diagrams.



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

4.2.6.7. Deflection measurements

Deflections shall be recorded at the beginning and end of each loading period to provide longitudinal and transverse deflections at the tower top, at the elevation of the cross arms and at least at one intermediate point of tower body.

4.2.6.8. Load tests

The initially applied loads and the increment of loading shall be 25 percent of the working loads given in the loading diagrams. However, the increments of load shall be in accordance with IEC 60652. Each load increment shall be maintained for not less than two minutes except that under full design load, the period of five minutes shall be maintained and during this time there shall be no slacking off or adjustment of the loads. Should it become necessary to adjust the loading, the two or five minutes period shall start after the loading is stabilized and constant. All test loads shall be removed completely before the loads for testing under different loading conditions are applied. The ultimate normal conditions or the most critical load case shall be the last test to be carried out in the presence of the Engineer.

Load Cell Calibration shall be carried out before and after each test or series of tests in the presence of the Engineer.

4.2.6.9. Destruction test

After the successful completion of the load tests, if specified, the tower shall be further tested to destruction by increasing the loads for a given loading case, as specified/approved by the Engineer. The load increment shall not exceed five percent of the full design loads. Each load increment shall be held at least five minutes while deflections are being recorded.

4.2.6.10. Modification of tower components

Any conspicuous yielding or permanent deformation or any failure of any part of the tower under any of the tests specified in Item g shall be considered a defect. If a defect develops, the Contractor shall modify the design of the tower and submit it to the Engineer for approval. The modified tower shall then be re-tested.

The expenses associated with re-design and re-test due to a defect in the Contractor's work shall be borne by the Contractor.

4.2.6.11. Material tests

Steel materials used for test towers shall be subject to tension or bend test in accordance with the relevant material standard. Tests shall be performed by the Contractor at no additional cost to the Employer. The test specimens shall be selected as follows:

- Four sets selected from the destruction members of each test tower.
- Four sets selected from the undisturbed members of each test tower.
- Two sets of bolts and nuts selected from the adjoining destruction members of each test tower.
- Two sets of bolts and nuts selected at random from each test tower.



4.2.6.12. Reports

The Contractor shall furnish certified copies of full reports of all tower and material tests, the calibration of the dynamometers or gauges, including clear photographs of the test set-ups and nature of all failures, diagrams showing deflection of towers at each interval of loadings, detailed diagrams showing the manner in which all the loads were applied and deflection records.

4.2.7. Packing and Shipping

The tower members shall be satisfactorily containerized or packaged in such a manner to protect them from damage during transportation, handling and for outdoor storage in hot, wet, humid and dusty condition. Where necessary, heavy parts shall be mounted on skid so that cable slings for handling can readily be attached. Where it is unsafe to apply external sling to a package, attached sling shall be provided and shall project through the package so that attachment can readily be made.

Plastic or rubber cushion shall be provided between layers of steel members in a package. Steel belts used for wrapping shall have gunny sack bounded underneath in such a manner to protect galvanizing of tower members.

Plates, bolts, nuts and washers shall be supplied in rigid cases.

4.2.8. Bill of materials

A bill of materials shall be submitted containing the size, length and galvanized weight of each member and the total weights of body, body extension and foundation stub conforming to the detailed drawings approved. It shall also include the number of bolts, nuts, washers and attachment devices per structure.

4.3. Cables

4.3.1. General

The scope of supply refers to the manufacture, supply, testing, packing, transport and delivery to site.

The Contractor shall carry out all works in skilled manner in compliance with modern methods of engineering. In addition, the Contractor shall conform to all applicable regulations regarding the manufacture and delivery of the goods and shall follow all instructions issued by Employer and the Engineer.

The conductors and earthwires to be supplied under the Contract shall comprise:

- Line conductor: One per phase Aluminum-magnesium-silicon alloy type (Almelec), code name 315-A3-37 according to IEC 61089.
- Earthwire: Two Optical Ground Wire (OPGW) Aluminum alloy – steel type, with a section equal to 116 mm². The OPGW shall be supplied on drums with sufficient lengths to be continuously installed between the joint boxes. The OPGW shall be in accordance with IEC 60794.

The conductors and OPGW manufacturer shall have ISO 9000 quality assurance system certified and shall prove a minimum experience in successful supply of similar cables of 5 years.



4.3.2. Standards and regulations

4.3.2.1. Basic standards

All materials and works referring to the manufacture, testing, packing and delivery of the conductors and OPGW provided under this Contract must be in accordance with the edition in force at the Bid Submission date of the following standards:

- EN 50183, EN 50326, EN 60889, EN 61232, CEI 60050-466, IEC 61089 for the conductors
- EN 61396, IEC 60794 (1, 2, 3 and 4) for the OPGW
- ISO 9001, 9002 and 9003 for quality assurance

4.3.2.2. Alternative standards

If the Contractor wishes to base his Bid on standards or codes other than those specified e.g. such authoritative standards appropriate to the country of manufacture, he may do so provided that he submits with his Bid complete data about the standards or codes applied and confirms in his Bid that such standards or codes meet, as a minimum, the requirements of the designated standards. The Contractor shall submit with and as a part of his Bid a tabulated list of the differences between the standards or codes applied and those designated herein.

The decision to accept such alternative standards or codes shall rest with the Engineer.

4.3.3. Design and manufacture

4.3.3.1. General

The conductors and OPGW shall be of design and construction as to ensure long service with high economy and low maintenance costs. They shall be suitable in every respect for continuous operation at nominal parameters as well as in transient operating conditions.

All materials used under this contract shall be of the best quality and workmanship shall be of the highest class throughout with the designs and dimensions of all parts such that the stresses to which the conductors and OPGW are subjected shall not render them liable to distortion or damage under the most severe conditions encountered during installation as well as in service.

Special attention shall be paid to the conductor and OPGW stranding process to ensure the necessary tightness between different layers in order to avoid slippage or relative movement of strands or cage formation during stringing.

Welds shall not be made in the aluminum wires, except when the wire breaks during stranding and, in these cases, the drum number and notice of existence of the weld is to be communicated to the Engineer.

4.3.3.2. Design data and performance

The main design data and performances of the conductors and OPGW earthwires are specified here below. All these data shall be proven by means of calculations or tests as specified.



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

4.3.4. Conductors

The selected line conductors are composed of Aluminum-magnesium-silicon alloy wires (Almelec).

The conductors' main characteristics are:

Specifications	Cable 366 mm ²
Code name is according to IEC 61089	315-A3-37
nominal cross section	366 mm ²
calculated diameter	24.8 mm
conductor structure	37x3.55 mm
Minimum ultimate strength	115.29 kN
Max DC resistance at 20°C	0.0916 Ohm/km
Linear Weight	1.0084 kg/m
Mean conductor length on drum	2000 meters

ALUMINUM ALLOY: Conductor: Stranded Aluminum alloy (greased in the inner and outer layers).

Specifications	Cable 570 mm ²
Standards	National NF C 34-125
Conductor shape	Circular
Type of cable	Aster
Conductor cross- section	570 mm ²
Total number of wires	61
Wire diameter	3.46 mm
Nominal overall diameter	31.05 mm
Approximate weight	1574 kg/km
External lay direction	S
Max. DC resistance of the conductor at 20 °C	0.0583 Ohm/km
Elongation coefficient	23 10E-6/°C
Final modulus of elasticity (MPa)	54000
Rated Strength	18.53 kN

The aluminum shall not be less than 99.5 per cent pure. The Contractor shall submit certificates of analysis giving the percentage and nature of aluminum impurities. The copper content shall not exceed 0.04 per cent. The cables shall be greased in accordance with the Standards.



4.3.5. Earthwire (OPGW) and telecom equipment

4.3.5.1. General

The optical fiber earthwire shall be of design and construction as to ensure long service with high economy and low maintenance costs. It shall be suitable in every respect for continuous operation at nominal parameters as well as in transient operating conditions, under the climatic conditions peculiar to the Site.

The standards and regulations mentioned above shall be observed in the design, construction and manufacture.

All materials used under this contract shall be of the best quality and workmanship shall be of the highest class throughout with the designs and dimensions of all parts such that the stresses to which the conductors and OPGW are subjected shall not render them liable to distortion or damage under the most severe conditions encountered during installation as well as in service.

Special attention shall be paid to the OPGW stranding process to ensure the necessary tightness between different layers in order to avoid slippage or relative movement of strands or cage formation during stringing.

4.3.5.2. OPGW characteristics

4.3.5.2.1. Main characteristics

The selected OPGW shall be Aluminum alloy – steel type with a section equal to 158 mm².

The main characteristics are:

Cable Structure

Optical Core:

Cables with 12 fibers

1 tube (red). With 12 fibers per tube. Without rings; blue, orange, green, brown, gray, white, red, natural, yellow, purple, pink, turquoise. Plus 3 black fillers

Aluminum Tube

Approximate inner diameter: 6.9mm

Approximate outer diameter: 9.9 mm

Maximum ovalization: 20%

Armor

Layer 1:

14 galvanized steel wires of 2.32 mm

2 aluminum alloy wires of 2.32 mm.

Covered with special grease with a high melting point for additional corrosion protection.

Winding direction to the right (Z).

Layer 2

22 wires of 2.32 mm aluminum alloy.

Winding direction to the left (S).

Cable Characteristics



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

Mechanics and Physics:

Approximate cable diameter:	19.2 mm
Approximate cable weight:	892 kg/km
Breaking load:	114 kN
Maximum allowable voltage:	80 kN
Maximum Charge recommends:	48 kN
Elasticity mold*:	103.7 N/mm ²
Section:	161 mm ²
Linear expansion coefficient:	$1.74 \times 10^{-6} \text{ }^{\circ}\text{C}^{-1}$
Minimum radius of curvature:	
On the pulleys:	400 mm
On brake devices:	750 mm
After deduction:	300 mm
Operating temperature: from -30 C to +70 C	
*for stress-tension calculation	

Electrical:

Electrical Resistance (20°C): 0.22 Ω /km

Short circuit from 25°C: 292 kA²s

Short circuit current for 0.5 s: 24.2 kA

The OPGW shall incorporate 12 optical fibers. They shall be greased in accordance with the Standards.

4.3.5.2.2. Optical Core Design

Individual optical fibers or groups of fibers shall be contained in protective tubes. These tubes shall form the fibers' secondary protection (the coating being the primary protection).

The optical core design shall be based upon the loose tube principles. This means that the cable design shall provide a strain margin. The function of loose tube and water screen may be covered the same physical component.

The optical core design shall prevent longitudinal fiber transport in the loose tubes.

A water block shall prevent longitudinal water penetration of the optical core and individual tubes. A metallic water screen shall prevent transversal water penetration of the optical core.

4.3.5.2.3. Loose Tube

The loose tube shall be made of PE (polyethylene) or metal. Elongation of the tube caused by cable elongation shall be in proportion to such cable elongation.

If the tube is located directly beneath the armor, the external dimensions of the tube shall be consistent with the internal dimensions of the armor.

The inside of the tube shall be smooth.

Concerning the steel tubes, If the tube has a welded seam, no welding debris shall be left inside the tube and there must be no transverse welds. Moreover, the tube shall be free of pinholes.

The tube shall not deform and shall continue to fulfill its function when subjected to the following:

- The electrical, thermal and mechanical loads stated in this generic specification



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

- The high-frequency (>1 Hz) and low-frequency (<1 Hz) vibrations occurring in the high-voltage line
- Use with the prescribed suspension and tensioning equipment and vibration dampers
- All regular and permissible conductor assembly processes

Non-circularity of the tube shall be $\leq 5\%$.

4.3.5.2.4. Water Screen

In case the water screen and loose tube are physically not the same, the relevant requirements stated above apply.

The water screen shall consist of a welded or extruded metallic tube.

In case of stainless steel tubes, aluminum cladding shall be applied in order to prevent corrosion.

OPGW types, manufactured with Water Screen of plastic tube are not accepted.

4.3.5.2.5. Optical fiber parameter and performance

The following characteristics of each optical fiber shall be applied for OPGW:

- transmission rate: 2.0 to 155.0 Mbit/sec
- transmission wavelength: 1310 nm and 1550 nm
- mode field diameter: 9.0 to 11.5 micrometers (μm), including tolerances
- optical cladding diameter: $125 \mu\text{m} \pm 2.4\%$
- cable attenuation: not greater than 0.38 dB/km for every fiber in every drum at optical wavelength of 1310 nm; and not greater than 0.25 dB/km for every fiber in every drum at optical wavelength of 1550 nm.
- joint attenuation: not greater than 0.10 dB at optical wavelength of 1310 nm or at 1550 nm for every fiber, measured on the fully installed joint
- core numerical aperture: less than 0.23
- life span: greater than 30 years

The Contractor is required to supply a graph of attenuation versus wavelength over the range of 1200 nm to 1600 nm.

No joints shall be allowed in any fiber in any drum length.

Discontinuities will be acceptable if:

- less than 0.10 dB in magnitude measured at 1310 nm, and
- ODTR traces from both ends of the cable at 1310 and 1550 nm wavelength show a difference of less than 0.05 dB/km for every fiber in every drum.

The Contractor shall state the refractive index of the optical fibers at 1310 nm and 1550 nm.

4.3.5.2.6. Fiber coating

The optical fibers are to be coated with a tight outer UV-hardened acrylate protective coating having a nominal diameter of $250 \mu\text{m} \pm 15 \mu\text{m}$.

The coating shall be mechanically easily removed over a length of up to 50 mm for the purpose of cleaning, cleaving and fusion splicing.



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

Each fiber is to be color coded in order to facilitate fiber identification. These coatings are to be colored fast, and shall not degrade the optical cladding/core neither mechanically nor optically.

The optical fiber coating material shall not generate H₂ gas around the optical fibers that will increase the optical loss as specified above over the designed life span of the optical fiber. The Contractor shall supply details of the methods employed to minimize the generation of H₂ gas.

The Contractor is to provide details of the coating material, dimensions and minimum bending radius of the coated fiber.

All coatings/colors are to be compatible with fusion splices utilizing the light inject detect (LID) method and profile alignment method.

4.3.5.2.7. Mechanical Characteristics

The Contractor shall state the minimum-bending radius for the cable under tension without incurring cable or fiber damage or optical attenuation increases.

In particular, the minimum allowable stringing sheave diameter shall be specified.

The Contractor shall also provide a graph or tabular data for a minimum-bending radius for all tensions from zero up to the maximum tension allowable on the OPGW without affecting its optical performance.

4.3.6. Tests

4.3.6.1. General test requirements for conductor

The conductors shall be subjected to type, sample and routine tests according to IEC 61089 and ISO 9001 to 9003.

4.3.6.2. General test requirements for OPGW

The conductors shall be subjected to type, sample and routine tests according to IEC 60794 (part 1-2) and ISO 9001 to 9003.

The Contractor shall nominate the type tests for OPGW he proposes for proving compliance with the requirements of this Specification. Tests nominated by the Contractor shall include but not be limited to:

- tensile test with indicated over length of fiber and simultaneously measured attenuation at 1310 nm and 1550 nm
- bending test
- repeated bending test
- crush test
- aging test
- water penetration test (tube)
- temperature test
- short circuit test
- lightning test
- stress-strain test



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

- creep test
- tests to verify the mechanical and optical performances of the optical fibers including OTDR (optical time domain reflectometer) tests.

The length of the optical fibers shall be subjected to a proof test at a minimum strain of 1.1 % on duration of at least 0.2 seconds. Only fibers, which pass this strain level, will be accepted. The Contractor shall supply details of the test method and references to any standards used, including a copy of the applied standards.

4.3.6.3. Tests after delivery

After the arrival of the conductors and/or OPGW at site, they will be inspected and shall pass to the satisfaction of the Owner/Engineer such of the tests set out above or the Standardization Rules as he may deem necessary to satisfy himself that the conductors and OPGW supplied conform to the Technical Specification, including Guaranteed Performances and Characteristics.

Conductors and OPGW which do not pass the tests satisfactorily may be rejected forthwith and shall be replaced at the Contractor's expense.

4.3.7. Spare parts

Spare conductors and OPGW, as per the price schedules shall be delivered together with the last scheduled dispatch and are to be provided in continuous lengths on non-returnable steel drums as specified.

The quantities of the spare conductors and OPGW are shown in the Bill of Quantity. Corresponding prices must be entered by the Contractor in this price list. If any additional quantities should be ordered after the date of the Taking-over Certificate, the prices may be subject to adjustment.

The spare conductors and OPGW have to be adequately protected against humidity, corrosion, etc. and packed and treated in such a manner as to be suitable for storage in the climatic conditions at the site, for an indefinite period. They shall be delivered on drums provided with identification labels stating also quantities. The spare conductors and OPGW shall be delivered to the Employer's stores and delivery will not be deemed to be completed until the packing material has been checked by the Engineer.

4.3.8. Packing, shipping, transport

The conductors and OPGW required for incorporation in the transmission line project shall be supplied on timber drums. The OPGW shall be shipped in continuous lengths. The packing for the corresponding spare parts shall comply with the requirements specified for long time storing.

The following requirements apply for packing and shipping:

- The conductors and OPGW shall be delivered and shipped on stoutly constructed timber or steel drums as specified and lapped with protective covering across the whole width of the drum. All drums with conductors and OPGW shall have a layer of waterproof wax paper or plastic sheet which must be safe against chemical reactions laid around the barrel under the conductors or OPGW and another one laid over them and under the lapping. Drums shall be securely fastened around the perimeter and shall be suitable for rolling on the flanges without causing damage to the conductors or OPGW.
- The disposal of all empty drums shall be the responsibility of the Contractor.



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

- The following information shall be clearly written in indelible paint on both flanges of each drum:
 - contract title and reference number;
 - manufacturer's name;
 - lifting instructions and limitations;
 - direction of rolling.
- An aluminum or painted metallic marking plate shall be fixed to each drum clearly showing the following data:
 - type and size;
 - length;
 - gross and net weight;
 - batch and drum numbers;
 - stranding date;
 - main dimensions of the drum;
 - correct direction of rolling.

Contractor shall submit a sketch or drawings showing the full details of drum design and the details of the proposed method of impregnation and lagging the inner drum surfaces with approved tarred paper or equivalent material. The minimum length of the conductor and earth wire in a drum is subject to the Engineer's approval.

4.4. Joints and Fittings

4.4.1. General

Complete insulator sets consisting of composite insulator units and assembling fittings as well as fittings for phase conductors and OPGW are required as described below. Specification requirements for insulators and fittings are listed in the following sections (see sketches here-below)

The Contractor shall provide detailed assembly drawings for each type of assembly required.

All clamps and fittings shall comply with the requirements of this Specification and must be approved by the Engineer. They shall be suitable for cable characteristics described in this document.

The Contractor shall ensure close and continuous liaison between the manufacturers of conductors, clamps, insulators and fittings so that the equipment will be perfectly adapted.

Besides, the Contractor shall assure perfect fitting of the insulator set and OPGW set fixing armatures to the tower steel construction.

All clamps and fittings shall be supplied by the same manufacturer. Splitting up of the supply of clamps and fittings will not be permitted.

In order to maintain low corona and low radio interference, the design of all clamps and fittings shall avoid sharp corners or projections, which would produce high electrical stress.

The design of adjacent metal parts and mating surfaces shall be such as to prevent corrosion of the contact surfaces and to maintain good electrical contact under service conditions.



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

Particular care shall be taken during manufacture of clamps and fittings and during subsequent handling to ensure smooth surfaces free from abrasion.

Adequate bearing area shall be provided between different fittings. Point contacts shall be avoided.

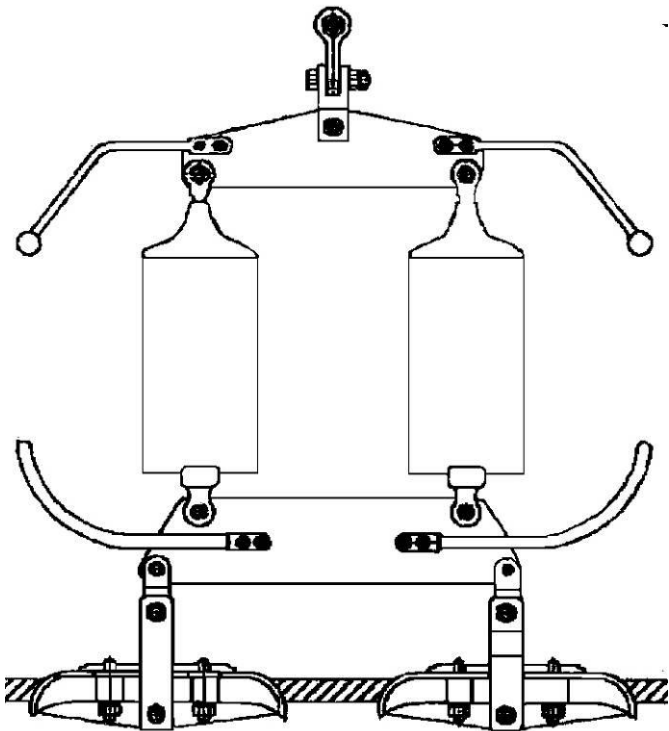
All ferrous parts of the assemblies component elements and of the accessories for conductors and OPGW shall be hot dip galvanized with a minimum zinc weight of 700 g/m², except bolts, nuts and washers where a minimum zinc weight of 500 g/m² will be accepted.

The split pins of all clamps and fittings shall be of stainless steel.

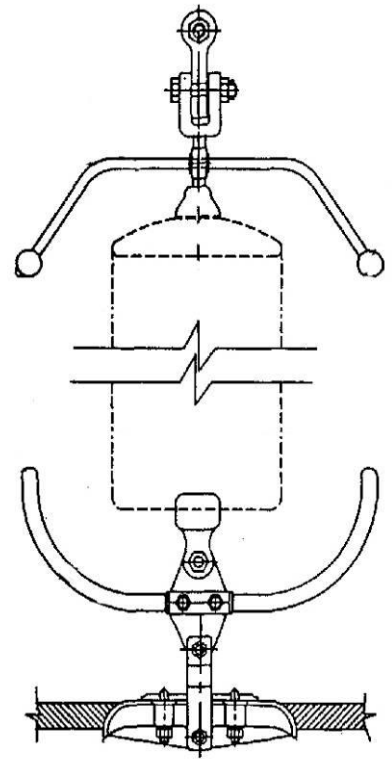
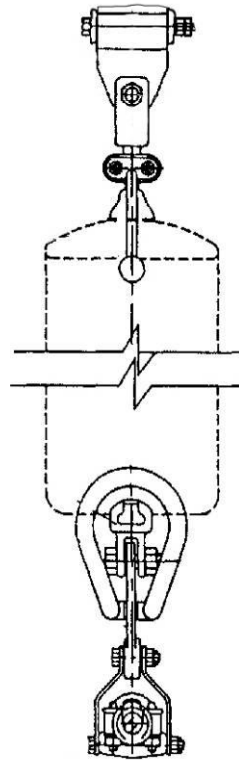


Overhead Transmission Lines

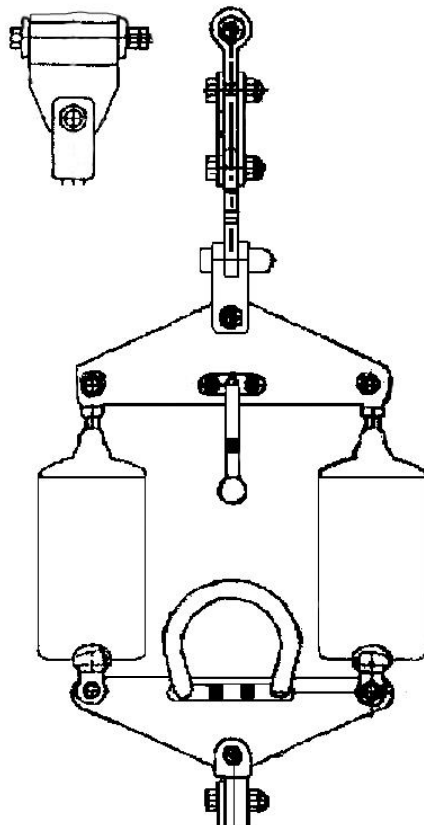
General Technical Specifications– Overhead Transmission Line



Typical Double suspension string



Typical single suspension string



Typical Double tension string



4.4.2. Insulators and insulator sets

4.4.2.1. General

The Contractor shall provide detailed assembly drawings for each type of assembly.

Composite insulator and fitting assemblies shall generally be in compliance with the typical assembly drawings included in this specification. Alternative designs will be acceptable provided that they are functionally similar and meet the performance specifications.

The insulator sets shall be designed for the aluminum type conductors defined in this document.

Single and double suspension insulator set and double tension insulator sets shall be used as per the drawings.

Spacing between double strings shall be sufficient to assure good behavior of insulators and good performance of guarding rings.

Special attention has to be paid to ensure that by breakage of an insulator string of a double set, the remaining string shall withstand the resulting static and dynamic stress by applying the specified safety factors detailed in these specifications.

For the dimensioning of the insulator sets from the mechanical point of view, the loads and loading conditions shown below as well as the safety factors given in these specifications.

4.4.2.2. Standards

The composite insulator must be designed, manufactured and tested according to the latest following standards:

- IEC 61952: “Insulators for overhead line – composite line post insulators for alternative current with a nominal voltage > 1000 V”. Tests methods – acceptance or failure criteria.
- IEC 61466-1: “Composite string insulator units for overhead lines with a nominal voltage greater than 1000 V”. Part 1: Standard strength classes and end fittings.
- IEC 61466-2: “Composite string insulator units for overhead lines with a nominal voltage greater than 1000 V”. Part 2: Dimensional and electrical characteristics.
- IEC Standard 60471, Dimensions of clevis and tongue couplings of string insulator units
- IEC Standard 60120, Ball and socket coupling of string insulator units

4.4.2.3. Design

The suspension and tension string insulator units shall be of the composite long-rod type, featuring a glass-fiber reinforcing epoxy rod core with high temperature vulcanized silicone rubber housing and clevis caps.

The insulators shall be of sufficient length to provide the required electrical performance in one single unit. In-line coupling of two or more units is not acceptable.

The general requirement of the insulators shall be as follows:

- Rated Strength (kN) : 120 kN



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

- Coupling device (according IEC 120) : 16 mm
- Dimensions
 - Insulator Length : 850 – 900 mm
 - Creepage distance min : 1980 mm

4.4.2.4. Requirements on Insulator Manufacturer

The manufacture shall have an adequate experience in the production of composite insulators for use at system voltage of 220kV - 66kV. As proof, the manufacturer shall submit a supply-list indicating type of insulator, quantity supplied, name and address of client, system voltage and year of delivery. Only such insulators shall be considered, for which a minimum 10 years manufacturing and successful service experience is available, without change of design and material. Preference shall be given to longer experience.

The Manufacturer of insulator units shall be certified in accordance to ISO 9000 series standards. He shall maintain a development and engineering department to provide technical-cum after sales service and information related to the insulators.

Each insulator shall be marked with the following information:

- Manufacturer's name or logo,
- Year of manufacturer,
- Guaranteed failing load,
- Identification code providing traceability.

4.4.2.5. Core

The core shall be made of fiberglass of "electrical" grade positioned in an epoxy resin matrix having high electrical, mechanical and thermal performances. Acid resistant glass fibers might be acceptable.

4.4.2.6. Housing and Sheds

The fiberglass/epoxy resin core of the composite insulator shall be protected by silicone housing. The housing shall be perfectly bonded to the core and to the fittings. High pressure/ high temperature direct injection molding is recommended.

The material shall be of blue/gray color and be resistant against the ultra-violet radiation being present in the solar spectrum at ground level. The track resistance of the material shall be min. class 1A 3.5 according to IEC 60587. The core-housing shall have a minimum thickness of 3 mm. The weather sheds shall provide an open aerodynamic profile without any under ribs. For the design of shed profiles IEC 60815 shall apply.

For a better efficiency of the leakage distance, the sheds must have a negative taper underneath. It is recommended, for insulators used in suspension string, to use alternating shed profile to improve the pollution performances.

To avoid arcing leading to degradation of the housing between the live end fitting and the last shed, this shed shall be directly applied on the live end fitting.



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

- For the Silicone housing, the elastomeric part shall contain 100% of Silicone gum before the introduction of fillers and additives. The manufacturer shall include in the gum suitable inhibiting components for preventing possible bird attack.
- The thickness of the rubber housing must be greater than 3mm at all points on the surface of the core of fiberglass/epoxy resin to protect it efficiently against electro erosion phenomena which the composite insulator will have to withstand during its life time.
- The interface joining the housing to the core must be uniform and without voids. It has to be obtained by high temperature vulcanization. The chemical bond between the core and the housing must be stronger than the tear strength of the housing material. The manufacturer shall prove that he masters non destructive technique to check the quality of the core to housing interface.
- The interface between end fittings and housing must be impenetrable and this property must be durable with time. A sealing made by a compression process is not acceptable. The preferred solution, to minimize the number of interfaces, is the direct bonding obtained by high pressure/high temperature injection molding with the same high temperature vulcanized material as per the housing, because of its better ageing and erosion performance compared to the sealing made of different materials (o-rings, silicone gel, RTV Silicone...or other sealing techniques shall not be considered as acceptable means of sealing).
- The housing and the interface end fittings/housing have to be designed to withstand high pressure water washing.

4.4.2.7. Metal Fittings

The metal end fittings should be made of forged steel or cast iron (malleable or ductile) and hot dip galvanized. The minimum mass of zinc should be in accordance with the clause 26.2.2 of IEC 60383-1 standard (min. thickness of 120 μm). Reinforced galvanization can be specified in coastal areas or locations where corrosive conditions are clearly identified.

The end fittings shall be attached to the core through a compression crimping process. The crimping process shall be controlled by a specific method (acoustic Emission, Accelerometer...) to ensure that there is no damage to the core during the compression crimping operation.

The gap between fitting and core housing shall be sealed permanently against the ingress of moisture. Sealing by compression only is not regarded to be permanently waterproof. Covering the cap, even partly, with housing material is unacceptable due to electrical reasons. Sealing of the interface by application of an elastomere with permanent elasticity is considered an acceptable solution. The material shall adhere to the surface of the metal cap, as well as to the housing.

4.4.3. Clamps and fittings for conductors

4.4.3.1. Suspension clamps

The conductor suspension clamps shall be of high-tensile corrosion-resistant aluminum alloy, suitable for a working temperature of 80°C. The clamping components shall be forged or cast. In case of casting additional reinforcing strap is foreseen.

The suspension clamps shall be as light as possible and of a vibration proof cover type. They shall be such as to form a fully articulated support for the conductors. The clamp bodies shall be



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

centrally pivoted and the rotational axis of the clamp shall be preferably at same level as the conductor center line or below but not above. The clamp body shall be able to pivot at least 45 degree above and below the horizontal line. Special attention shall be paid to the mass moment of inertia of the clamp in order to avoid resonance of the clamp plus conductor system by wind induced vibrations. The Contractor shall ensure by appropriate calculations and design a suitable suspension clamp for the specified conditions.

The phase conductors shall be protected within the suspension clamps by means of armor rods and the dimensions of clamps shall allow for this requirement. The armor rods shall be designed in such a way as to strengthen the conductor or OPGW in the suspension points and to reduce the static and dynamic bending strains in the strand wires of the outer conductor layer.

The suspension clamp components shall be dimensioned and shaped in such a way that no undue crushing or bending stresses are imposed upon the conductors and armor rods.

The conductor supporting groove shall be curved at its ends in the vertical plan to an appropriate radius to permit the conductor to leave the clamp at the maximum angle of inclination (20 deg).

The mouth of the supporting groove shall be slightly flared in plan. The grooves in the clamping piece shall be bell-mouthed at each end and all conductor grooves and bell-mouths shall be smooth and free from waves, ridges or other irregularities.

The bolts used in the suspension clamps shall be hexagonal hot-dip galvanized (500 g/m²) or stainless steel bolts. The washers underneath the bolt head shall be made from stainless steel only.

Subsequent to tightening of bolts to the torque as recommended by the manufacturer, the clamp shall be capable of withstanding the maximum working tension of the conductor without any conductor slippage. They shall permit the conductor to slip at a load lower than the conductor breaking load.

The clamp bolts and the clamping force shall be chosen to satisfy also the electrical requirements.

Attention must be paid to the elimination of fair weather corona emission from all parts of conductor suspension clamps under the specific site conditions.

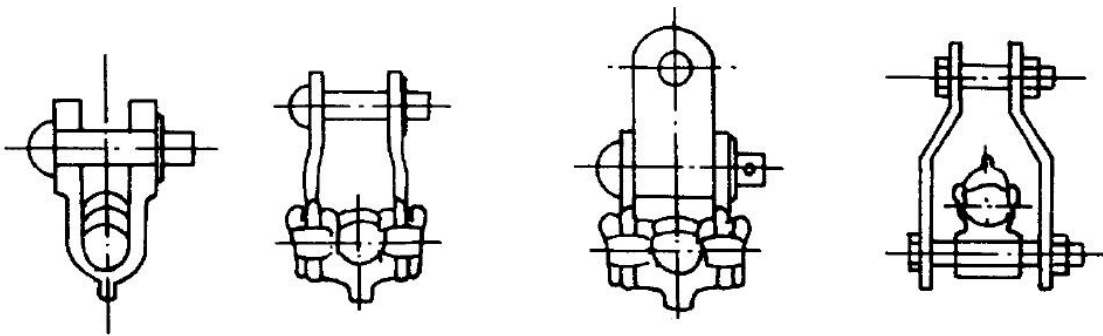


Figure 1 – Typical suspension clamps

4.4.3.2. Tension clamps, joints and repair sleeves for conductor

Tension clamps and joints

Conductor tension clamps and joints shall be of the compression type, suitable to withstand a working temperature of 80°C. The conductor tension clamps shall be supplied with a jumper terminal which may be bolted at 0° or 30°. The coupling element of the tension clamps to the string shall be clevis-type, hot dip galvanized.

The electrical conductivity and current carrying capacity of the tension clamps, joints and jumper terminals shall be not less than those of the equivalent length of conductor.

The tension clamps and joints of the phase conductors must be capable to withstand also the three phases short-circuit current without damage.

Attention must be paid to avoid fair weather corona emission from the conductor tension clamps and joints.

Compression-type clamps and joints shall be tested by the Contractor to ensure that they will stand up to at least 95 per cent of the rated ultimate strength of the conductor.

Joints and tension clamps shall be made of aluminum alloy.

Joints and tension clamps shall be supplied with filler compounds, to protect the assembly clamp-conductor against corrosion.

The split pins used shall be of stainless steel.

The design of the joints and tension clamps shall be such that only one pair of dies is necessary for the compression of the conductor.

Mid-span joints shall not be less than 25m from the nearest conductor clamp.

Joint and repair sleeves

Conductor repair sleeves shall not be used without the permission of the Engineer which will be granted only in exceptional circumstances.

Joint sleeves and repair sleeves for the conductors shall be of compression type. The joint sleeves shall consist of aluminum compression sleeve. The aluminum compression sleeves shall be of aluminum alloy conforming to the specification in IEC 60889 standard.

After compressed, the electrical resistance of the joint sleeve must be less than that of the jointed conductor with the same length as the sleeve, and the ultimate tensile strength of the joint sleeve must not less than 95% of the ultimate tensile strength of the conductor.

4.4.3.3. Armor rods

Preformed armor rods shall be used to protect the phase conductors in suspension assemblies.

The direction of the armor rod lay shall be equal to the direction of the outermost wire lay of the conductor.



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

The suspension clamps offered for the phase conductors shall accommodate the increased diameter resulting from armor rods.

The ends of the armor rod wires shall be well rounded, without sharp edges, to avoid an increase in corona level.

4.4.3.4. Guard rings

The guard rings of the insulator sets must fulfill simultaneously the functions of arcing rings, corona shield and potential distribution devices.

As arcing device, the guard rings shall be designed to protect insulators and conductors when flashover occurs. The arcing fittings shall be made of hot dip galvanized steel and must have the capability to withstand a short circuit current of 40kA for 1 second. The arcing fittings must be designed so that in case of flashover the arc will be led to the end burning spot. They may reach a final temperature not exceeding 600°C during short-circuit. The function of arcing protection must not be greatly altered by the power arc.

As corona shield devices, the guard rings shall be designed to ensure under fair weather and under the specific site conditions a corona-free insulator set line end as well as the specified insulator set radio noise performance. As shown on the drawing, the tension insulator strings shall be equipped with additional guard rings for corona purposes.

As potential distribution devices, the guard rings must be designed to insure a uniform distribution of the potential along the insulator string.

The design of the guard rings shall consider and optimize simultaneously all the functions required.

The rings shall be strong enough to support a weight of 90kg without permanent deformation. The ring attachment shall be via bolted connections to the hardware assembly.

4.4.3.5. Tests

The tests of material shall be conducted according to IEC 61284, IEC 61109, IEC 60383-2 IEC 60437, IEC 60507 and EN 50182.

4.4.4. OPGW connection-to-tower sets

4.4.4.1. General

Complete assemblies of clamps and fittings for these OPGW are required, as described below. Specification requirements for the assemblies as well as for the individual clamps and fittings are listed in the following sections.

The Contractor shall provide detailed assembly drawings for each type of assembly required.

The Engineer shall approve assemblies and their components.

The suspension towers will be equipped with suspension sets and the tension towers with tension sets. All sets shall be designed for the OPGW selected type and for the mechanical loads and loading conditions shown below as well as the safety factors given in Data Sheet.



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

It is to be mentioned that the OPGW stringing condition shall take into account that the sag of the OPGW shall not be greater than that of the phase conductor sag under everyday temperature condition.

At all suspension, tension towers and Substation gantries, the OPGW shall be electrically connected to the steelwork by means of jumpers of the same size and material as the OPGW as well as by means of suitable fittings.

The design of adjacent metal parts and mating surfaces of the assembly components shall be such as to prevent corrosion of the contact surfaces and to maintain good electrical contact under service conditions. Adequate bearing area shall be provided between different fittings. Point contacts shall be avoided. Particular care shall be taken during manufacture of clamps and fittings and during subsequent handling to ensure smooth surfaces free from abrasion.

All clamps and fittings shall be supplied by the same manufacturer. Subject to the Engineer's approval, the vibration dampers could be supplied by a different manufacturer.

All ferrous parts of the assembly components shall be hot dip galvanized with a minimum zinc weight of 700 g/m², except for bolts, nuts and washers where a minimum zinc weight of 500 g/m² will be accepted. The split pins of all clamps and fittings shall be of stainless steel.

4.4.4.2. Suspension assemblies

Armor grip suspension clamps shall be used for OPGW. The clamp body shall be of high-tensile corrosion-resistant aluminum alloy and shall be preferably forged. The spiral wires shall also be of aluminum alloy and shall not have diameters less than 4 mm.

The neoprene or other non-metallic material shall have good resistance to aging and be capable of withstanding temperatures between 0°C and 80°C without changing of essential properties. The material shall have adequate resistance to the effects of ultra-violet radiation, ozone or pollution factors.

The clamp body shall be able to pivot up to 45 degrees above and below the horizontal line. The Contractor shall ensure by appropriate design a suitable performance of the clamp-conductor assembly by wind induced vibration. The clamp body shall have provision for connecting the OPGW to the tower.

In addition to the suspension clamp, several other fittings are required for a suitable mechanical and electrical connection to tower and the Contractor is responsible to supply the complete set of the suspension assembly.

4.4.4.3. Tension assemblies

The OPGW attachments to tower shall be of helical grip type consisting of two helical parts (fittings), one for OPGW protection and the other one as actual dead-end fitting. Preformed helical dead-ends shall have "cabled loop" eyes. The material of the spiral wires shall be high-tensile aluminum clad steel. The protection part is defined to protect the earth wire against radial forces in the OPGW produced by the high longitudinal tensions during operation. The protection part must be laid in the opposite direction of the outer layer of the OPGW and the dead-end part must be laid in opposite direction to the protection part. The grip strength shall be at least 95 % of the ultimate tensile strength of the OPGW.

The tension attachment devices must correspond to the OPGW type and dimensions. The protection part must be longer than the tension (dead-end) part and must be sufficient to install



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

vibration dampers. The number and diameter of the spiral wires of the two parts are generally different but must be coordinated to meet the operational requirements.

Special tension assemblies shall be installed on suspension towers if necessary. The design shall be established in order not to create stress on the tower.

4.4.4.4. Mid span joints for OPGW

The OPGW shall not be jointed in the spans.

4.4.4.5. Tests

The tests of material shall be conducted according to IEC 61284, IEC 61109, IEC 60383-2 IEC 60437 and IEC 60507.

4.4.5. Antivibration systems

Antivibration jumpers shall be installed on conductors for all suspension towers. The design shall be approved by the Engineer.

Vibration dampers of Stockbridge type shall be additionally fitted at all OPGW suspension and tension points, minimum one damper per span.

Regarding the damping characteristics of the vibration damper, the Contractor shall guarantee that close to the suspension clamps as well as to the damper own clamp, the amplitudes of the wind and wake-induced vibrations are kept within acceptable limits over the entire range of possible frequencies.

The Contractor shall submit all data and calculations regarding the characteristics, number and placement of the vibration dampers to be used for the various ranges of spans. The calculations shall take into considerations the local conditions of the terrain morphology, the wind velocities and directions and the medium level above soil of the conductors and OPGW. All data for the calculations shall be in responsibility of the Contractor and shall be subject for approval of the Engineer.

The damper clamps which are in direct contact with the OPGW shall be of forged aluminum alloy and shall be designed to ensure that dampers do not damage the conductors and OPGW for which they are used.

As function of the necessary distance between the first vibration damper and the mouth of the suspension clamp on the phase conductor, the damper clamp shall be dimensioned taking into account the installation on conductor or on the armor rods.

The clamping bolts shall be of steel having a minimum tensile strength of 80 N/mm² and shall be designed to facilitate an easy damper mounting. The screws shall be locked in an approved manner. The washers shall be made of stainless steel.

The damper shall be designed to eliminate water collection. If this is not possible, they shall have drainage holes with a minimum diameter of 6 mm.

All ferrous parts of the damper component elements shall be hot dip galvanized with a minimum zinc weight of 700 g/m² except bolts and nuts where a minimum zinc weight of 500 g/m² will be acceptable.

The design and tests of antivibration Dampers shall be conducted according with IEC 61897.



4.4.6. OPGW splicing

On the Substation gantries and on tension towers connections between OPGW shall be realized by means of joints in Joint Boxes.

At the tension towers not provided with Joint Boxes, the Contractor shall provide suitable attachment fittings to by-pass the tower without any additional joint.

The joints will be located in a suitable position in the tower knowing that the splices shall be executed on the ground level.

The Contractor shall present by means of detailed description and drawings, the OPGW jointing procedure and devices and is responsible for the operational continuity of the optical fiber system.

Locking facilities and weatherproof units shall be provided for the joint boxes (enclosures). The joint boxes shall include all necessary hardware to terminate, protect and fix the spliced fibers. Optical losses shall average at no more than 0.06 dB per splice and no single splice loss shall exceed 0.15 dB. Each splice shall have a spare length of fiber of approximately 1 m or more. A finished splice shall be supported within the joint box by suitable clips or restraints. It shall be possible to remove and replace the splice in the support device without risk of damage to the splice or fiber.

The inlets of the joint boxes shall be sealed with thermo fit plastics. There inlets shall be possible to match necessary branches. The outer material of the box shall be oil resistant and metallic, preferably aluminum.

Further requirements for the enclosures are as follows:

- The Contractor shall provide detailed specification for mechanical and optical aspects of all joints, splices and end-sealing arrangement for the individual parts and/or complete system.
- The quality and performance of all joints shall be consistent with achieving the mechanical requirements over its design life.
- The Contractor shall describe in detail the proposed method of jointing the optical fiber both during manufacture and installation.
- The Contractor shall provide detailed drawings showing the location of all joints. Each joint shall be uniquely numbered.
- As part of the jointing procedure the Contractor shall monitor the optical performance of each joint using an Optical Time Domain Reflectometer. Upon completion of jointing and prior to sealing the joint enclosure an estimate of joint loss and measurement of the total fiber attenuation shall be made. If the total fiber loss is projected to exceed the designed installation loss then the joint shall be broken and rejoined until the specified performance is achieved.
- It shall support, organize and protect the optical fibers and the fiber splices whilst ensuring that the optical fiber minimum bending radius is not exceeded.
- The fusion splice tray shall not have any sharp edges or protrusions which may damage the optical fiber.
- An encapsulate shall not be used.

All documents supplied by the Contractor shall be submitted in time so that any comment and change required by the Engineer can be taken into account before starting of the manufacture in the workshop.



4.5. Aircraft warning system

4.5.1.1. Warning spheres

Warning spheres shall be fitted to the OPGW of the transmission line on span which length exceed 700 meters and where specified by the Employer or the Local Authorities.

The warning spheres shall be 600 mm diameter and manufactured from fiberglass. The spheres shall be colored white and red which will not fade when subjected to the direct rays of the sun.

They shall be manufactured in two halves and designed such that assembly and attachment to the OPGW is simple. Suitable clamping devices shall be provided to fit the warning spheres on OPGW locally protected by armor rods, which will not damage the OPGW but will prevent the sphere from twisting or slipping on the OPGW. All metal parts used for holding the spheres in position shall be of mild steel and galvanized.

The position of the spheres shall meet the following requirements:

- The spheres on both OPGW for any span shall be so staggered that the maximum distance between any two spheres is not greater than 60 m or according to international or local regulations.
- The type and details of the spheres shall be closely coordinated with the OPGW manufacturer in order to avoid any excessive stress on the OPGW.

4.5.1.2. Tower warning lights

Tower warning lights shall be fitted on the top of the towers separating spans that exceed 700 meters and where specified by the Employer or the Local Authorities.

Solar-Powered LED lights for electric towers performing in Harsh Environments, completely contained, to be installed on top of electric towers, each unit is consisting of:

- a- Solar power photovoltaic panel, LED lights, rechargeable batteries, and power management system, all waterproof products.
- b- System of command (photocell) automatically turns lights ON at sunset (or once the ambient light threshold passed) and OFF at sunrise (or once the ambient light threshold surpassed). Intensity step changing: Night \geq 2000 candelas.
- c- Copper earthing connections for lightening protection.
- d- The base with fixtures to install the unit on the electric towers (drawings to be submitted).

The reference codes are ICAO type C for RED steady medium intensity color requirements.

Approval as per ICAO annex 14 or equivalent standard.

Surge/Lightning Protection: Beacon designed to withstand IEC61000-4-5.

The time of operation without maintenance (or MTBF) in years should be indicated in the offer

Led light source with a life exceeding 100,000 hours.

The light output is multidirectional red steady with medium intensity, ICAO type C.

The charging of batteries should continue even in cloudy weather.

Minimum Autonomy = 200 hours.

Minimum Equivalent Peak Sun hours (to maintain Minimum Autonomy) should be indicated in the offer.

The ambient temperature range is -10 °C to + 40 °C, and Humidity 90%.



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

The solar panel and the LED lantern should be UV-protected, domed or with incorporated spike (detering unwelcome bird life) to stay clean; all structures and fixtures of the unit should be anticorrosive material.

Batteries should be recyclable and user replaceable.

Dust and moisture sealing: IP 65 for light and IP 55 for control gear.

The test will be done on all units in presence of EDL agent, and if any unit shows a faulty function then the supplier must replace it by new one until tests become satisfactory.

The tests are done as follow:

- Test of solar power and battery charging.
- Test of lights.
- Test of ON, OFF switching.

Works

4.6. General

The works to be executed by the Contractor are defined here below and in the Particular Technical Specifications relative to the line to be executed.

The Contractor shall execute all necessary works till the full completion of the line which shall be operable in normal conditions.

The following list is only a summary of the works to be executed by the Contractor and therefore is not limitative:

- Line route survey
- Towers staking
- Vegetation clearing
- Access roads and platforms
- Delivery of all necessary materials
- Geotechnical studies
- Excavations
- Foundations
- Earthing system
- Erection of towers
- Stringing and sagging of conductors and OPGW
- OPGW splicing in joint boxes
- Aerial, danger and number plates
- All facilities in order to ensure safety during all parts of the works
- Compensations for damages
- Site cleaning

4.7. Preliminary work

4.7.1. Line Route Survey

The Contractor shall perform all necessary survey work which consists of determination, checking and laying out the accurate center line and elevation of all the reference points, based on the drawings. Should an angle point marker be disturbed or destroyed, it shall be re-established by the Contractor using reference ties set by the Employer at his expenses.



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

The Contractor shall execute the tower spotting employing technical data furnished by the Employer on the plan and profile drawings.

The Contractor shall check the minimum clearance of conductor crossing the existing highway, major waterway, telecommunication lines, power lines and any other object that will create less vertical clearance than that required.

During the survey, if not enough side clearance is found, the Contractor shall perform side clearance survey and submit to the Employer along with recommendation for the solution of problem.

Not less than 15 days prior to the commencement of the work, the Contractor shall submit qualifications of personnel, work program and list of survey equipment for reviewing by the Employer.

Two (2) copies of corrected key map, plan & profile drawings, structure lists, check survey data, six (6) copies of diagonal profile and plan drawings of hill side structures including the proposed individual leg extension shall be submitted to the Engineer.

4.7.2. Towers Staking

Three stakes will be provided on the center line of the transmission line. One (1) stake at the station of the proposed tower location and the other two (2) reference stakes will be located on the center line of transmission line, 10 m ahead and behind the center stake. The top of the center stake shall be driven to an elevation to be known as the working point from which the line and grade of the tower shall be established. The line station and elevation of the top of the stakes shall be marked on the sides of each stake. The Contractor shall provide adequate protection for these stakes to prevent disturbance during right-of-way clearing, site preparation and construction.

4.7.3. Line schedule check

The Contractor shall confirm all towers at the positions shown on the plan and profile drawings. If the site of any tower as spotted in the plan and profile drawings is not suitable by reasons of topographical, geological or any other affecting conditions, the Contractor shall be required to recommend alternative locations of the towers to the Engineer for consideration. The Contractor shall carry out the work in accordance with the Employer's decision.

4.7.4. Line route pegs

The Contractor shall prepare diagonal cross sections of all tower locations, to determine leg extensions or reductions, foundation platform, protection requirements and foundation setting levels.

It shall be ensured that the foundation caps will have a minimum height of 0.30m above final ground level.

Angle and terminal towers shall be placed within survey accuracy limits (see above). Straight line towers shall be located and centered within 0.10m of the centre line transversely and within a 0.5 % deviation of their back span length longitudinally, relative to their specified position on the profile plan.

Line route pegs are provided on the center line of the transmission line. The Contractor shall verify and provide adequate protection for these pegs to prevent disturbance during easement clearing, site preparation and construction.



4.7.5. Tower relocation and route realignment

If during the construction, tower sites have to be relocated and the line route realigned, the Contractor shall carry out the tower site realignment survey, which shall be considered as included in the Contract lump sum price. The tower site survey shall include the survey for the centre peg, left and right reference pegs and diagonal levels.

4.7.6. Route modifications

For route modifications agreed with the Engineer, the Contractor shall carry out a complete line verification and control of the longitudinal profile drawings including the necessary uphill side slope information, plotting of the towers, pegging the tower positions in site and surveying diagonal profiles for determination of disheveled legs - complete as required for the project.

4.7.7. Vegetation clearing

4.7.7.1. Easement clearing

The Contractor shall survey and mark the vegetation within the specified easement of the proposed line route. The easement for the given in the drawings.

The Contractor shall take the necessary precautions to avoid damage to trees when carrying out the easement clearing. The compensation or consequences caused by any damage, which in the opinion of the Engineer could be avoided, shall be borne by the Contractor.

The Contractor shall take all appropriate precautions when clearing vegetation in the vicinity of public buildings, streams, roads and private houses, etc. Fallen trees shall be removed from these specified areas immediately after clearing. Any damage caused by carelessness, ignorance and over-sight shall be compensated by the Contractor.

4.7.7.2. Danger tree clearing

The Engineer shall be advised of all tall trees outside the general cleared area, which could endanger the safe operation of the line. The Contractor is required to identify the dangerous trees at least four weeks before commencement of stringing. The Contractor is responsible for obtaining the landowner authorization and appropriate compensation costs shall be born by the Contractor.

The Contractor shall also take all precautions to avoid damage to crops, which are not considered as danger trees when felling the dangerous trees. Any compensation or other consequences of damage shall be borne by the Contractor.

4.7.7.3. Re-clearing

Before the issuance of the Taking Over Certificate, the Contractor shall have re-cleared the vegetation within the easement to the standard specified.



4.7.8. Way leave

4.7.8.1. General

The Contractor shall engage sufficient local Public Relations Officers, who shall be assessed as suitable by the Employer, to liaise with Landowner etc. on matters of way leave, access and damage and they shall be engaged full-time for the duration of construction works for the portion covered by the officer.

4.7.8.2. Damage to crops and property

The Contractor shall take all precautions to avoid damage to public, land, property, crops, etc. and shall ensure that the work is adequately supervised so that damage is avoided. All surplus material shall be removed after erection and the site shall be left in a clean and tidy condition, to the satisfaction of the Engineer.

Where the Contractor causes damage, he shall be responsible for reinstatement and/or compensation. If, in such circumstances, the Contractor shall fail to settle compensation to the extent that, in the Engineer's opinion, the progress of the works is likely to suffer, the Employer shall negotiate and settle the matter and the cost shall be deducted from moneys due to the Contractor.

4.7.8.3. Protection of real estate and livestock

The Contractor shall limit the movement of his crew and equipment on the right-of-way and on approved access routes, so as to minimize damage to crops, orchards, or property and shall endeavor to avoid marring the lands. Ruts and scars shall be obliterated, damage to ditches, terraces, roads and other features of the land shall be corrected and the land shall be restored in its original condition.

The Contractor shall be responsible for any damage to crops or lands resulting from his operations.

The Contractor shall be responsible to the occupants of the land which are crossed by the transmission line for any damage to personal property resulting from his fault or negligence, including damage caused by straying livestock and he shall make prompt settlement of damages to personal property resulting from his negligence.

The Contractor shall be responsible for notifying the Employer in writing of all instances of damage to crops plantation, livestock, etc...

4.7.9. Access

4.7.9.1. General

The Contractor shall at an early stage of the Contract examine the line route and prepare access maps showing his proposed entry routes to all parts of the line and the type of plant or transport intended to traverse the routes. The maps shall indicate the types of access to be constructed, the places where it is proposed to use existing roads, community roads and existing roads not maintained by government or other statutory authorities, or by proposed new tracks.



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

The Contractor shall avoid using private access belonging to individual house to gain access to the site. Any damages to their lands must be repaired to the satisfaction of the house owners.

The Contractor shall arrange his own store yard for storing of materials and equipment.

The Contractor shall be responsible for all relative costs due to the execution of access roads (including survey, works, delay, compensation for damages...)

4.7.9.2. Existing access

Where the Contractor uses government or other statutory authority maintained roads to enter the sites for construction purposes, he shall maintain these accesses in perfect state during the construction period.

However, when the Contractor has approval to use existing community roads which are not maintained by government or other statutory authorities, he shall get the consent from the concerned Landowner and shall undertake to maintain the road during the line construction to such a standard that its use by the customary traffic is not impeded in any way. He shall then restore the road to a condition equal to that existing before the start of line construction and such restoration shall be completed before the issue of the Taking-Over Certificate.

Culverts and bridges:

Temporary culverts and bridges which are deemed to be included in the new access road rate shall be provided at low points of the new access. The culvert shall be of different sizes and of reinforced concrete pipe sufficient to prevent retention of flood waters upstream of the access.

The types of culverts and bridges proposed by the Contractor shall be approved by the Engineer.

4.8. Foundations

4.8.1. General

The execution of tower foundations shall include the following works:

- Preparation of the access roads
- Excavation works
- Execution of the necessary preliminary works before concreting of the foundations (anchors, grouting, coned shapes, soil exchange, compaction, etc.)
- Execution of foundations
- Backfilling works
- Cleaning of the site and transport of all superfluous materials.

The contractor shall execute the removal of all vegetation and other debris from the tower site which will interfere with his operation. Tower site preparation shall be done in a manner which will prevent revision of the foundation designs or requirements for leg or body extensions. Vegetation and debris removed from the tower location shall be disposed off outside the right of way as directed by the Engineer and/or in accordance with local regulations.

The depth of the foundations shall always be related to the lowest ground and not to the platform/fill elevation in the area occupied by the foundation.

The payment of foundations quantities shall be based on the approved design and the approved class of soil.



4.8.2. Design

4.8.2.1. General

The foundation for towers shall be:

- In the areas with submerged and poor soil conditions, the use of pile foundations is proposed to be used.
- Reinforced concrete pad and chimney foundations for normal soil conditions.

The Contractor shall propose undercuts for soils class 3, 4 and 5.

The type of foundations specified here above are not obligatory to be used by the Contractor. He can select also other type and alternative solutions for the foundations which are considered more economical or more adequate for the effective soil and topographical conditions of the Transmission Line.

The different - alternative - solutions proposed by the Contractor must guarantee that following conditions and criteria:

- identical or higher safety in all aspects for the proposed foundation type(s)
- the experience of the Contractor with similar foundations of the new proposal executed in the same conditions for High Voltage Transmission Lines
- availability and applicability of his equipment for the execution of foundations in the difficult project area.
- testing methods for the alternative proposal.

The Contractor shall state out the tower locations and submit to the Engineer the foundation conditions including permissible bearing pressure expected at each tower together with the type of foundation considered applicable by him.

After the performance of the excavations, the Engineer may require the Contractor to make additional soil investigations at tower sites to verify the effective soil conditions at no additional cost.

The Contractor shall submit to the Engineer the calculation of each typical foundation type with clear information about:

- the maximum compression and uplift as well as horizontal loads without safety factors
- the stability of the foundations with respect to uplift, compression and horizontal loading calculated according to the safety factors. The effective pressure of the soil shall not exceed the limits calculated by the Contractor on the basis of the data of the soil investigation report. The calculations are subject to the approval of the Engineer. Unless otherwise directed all tower foundations shall be designed as individual leg foundations, four foundations per tower.

Any information given in the Technical Specification in relation to the foundation design is for tendering purpose only. For the final foundation design the Contractor has to perform the required soil investigations and has to base his design calculations on the detailed information obtained. The Contractor is requested to quote firm unit rates for the different types of foundations and towers. These unit rates will be considered as flat rates covering all foundation costs for any type of soil encountered along the line and no adjustment of the rates will be permitted.



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

4.8.2.2. Soil characteristics

After determining the specific soil characteristics, for each tower foundation the applicable type of foundation shall be defined.

Where, in the opinion of the Engineer, after examination of the effective soil conditions, the nature of the ground warrants, the Contractor shall carry out further tests according to the instructions of the Engineer, until satisfactory information is obtained on the ground bearing properties and foundation type, at not additional cost.

The Contractor shall finalize the design of each type of the foundations in accordance with the results of soil investigation report. A selection of the foundation type shall be made for each tower to suit its particular site conditions and the final tower list prepared there-from. The tower foundation list shall be submitted for approval to the Engineer.

4.8.2.3. Calculations

The Contractor shall submit detailed calculations for approval showing that the ultimate earth bearing capacity is not exceeded by the maximum pressure due to loads, acting on the tower, multiplied with the corresponding safety factor and due to the dead weight of the tower and foundation.

The design shall further prove that the uplift forces on the foundation do not exceed the weight of the fictive anchor body in the soil, assumed to be in the shape of an inverted pyramid starting 25 cm above the toe of the pile. Alternative, methods of design can be adopted subject to Engineer's approval.

The Contractor shall also submit the Engineer calculations and drawings showing the bearing capacity and stresses at each critical section of the concrete and the selection of the steel reinforcement.

In the calculations and drawings the Contractor must state clearly whether the calculations for pad & chimney foundations are made for "undercut conditions" and pouring the concrete directly against the soil surface or for "no undercut conditions" and pouring the concrete inside formwork.

All relevant calculations and checks are to be established with the following as minimum:

- permissible soil pressure, effective pile load, effective anchoring,
- settlements (compatibility with structure above to be proved)
- sliding
- shear failure (including slope stability if applicable)
- uplift safety
- permissible concrete/steel stresses
- protection against aggressive soil conditions by appropriate measures

4.8.2.4. Caps

In locations liable to flooding, all part of the tower or part of the stub-angle foundation shall be completely encased in concrete to ensure a concrete cover of 100mm.



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

All concrete foundations shall not be less than 350mm above the final ground and shall be of dense concrete. They shall be sloped off around the steel leg section and smoothly finished to ensure drainage away from the steel work. No capping shall be commenced in any portion of the work until the designed portion has been approved by the Engineer.

4.8.2.5. Foundations stabilization

At locations where earth moving (e.g. land slides, erosion, etc...) is likely to occur, the tower foundation and leg structure shall be protected against this effect by means of backfilling and/or layers of stabilizing material/soil to prevent erosion.

Any stabilizing layer (e.g. batch or other approved material has to be laid in well compacted layers to have a thickness of not less than 50 cm. The protected area should reach at least 5.0 m beyond the edge of the foundations.

The tower locations where such protections are needed shall be finally decided upon by the representative of the Engineer as subject to approval of the Engineer at site. Appropriate safe solutions shall be proposed by the Contractor.

4.8.3. Soil investigations

4.8.3.1. General

The Contractor shall be responsible at his own cost for ascertaining that the foundations to be employed are suitable for the sub-soils encountered at each tower and support site at an early stage of the contract.

Detailed soil investigations shall be carried out by the Contractor along the line route as a prerequisite for planning of the foundations. The extent of the investigations shall be such as to permit the satisfactory determination of all necessary sub-soil characteristics, to exclude any unacceptable settlement and to determine reliable type, size and execution of foundations. These investigations have to be completed before the design works start. The soil investigation report shall contain details also regarding the earthing system to be provided for of each tower location.

4.8.3.2. Quality assurance

The following references have to be submitted to the Engineer for approval prior to start of any field work.

Experience in soil investigation work

The field works shall be done by a competent company and staff experienced in soil and rock drilling techniques. Accordingly, the Contractor shall show proof of an adequate inventory of drill rigs, drilling equipment, rock coring equipment, sounding equipment and the necessary testing facilities.

Experience in foundation engineering

The Contractor shall name a professional soil mechanics expert and foundation engineering expert.

The soil report containing the description of the soil conditions and the foundation engineering proposals is to be made by this expert and is to be signed by him. The expert shall supervise the boring works.



Codes and standards

The Contractor shall comply with all local laws, rules and regulations applicable to the work. The investigation procedures shall be governed by international standards and codes.

4.8.3.3. Investigations

For classifying type of foundation, the Contractor shall carry out bore hole investigations at all tension tower locations and every 5 suspension towers minimum.

The above mentioned criteria can be modified by the Contractor if the soil conditions are on a longer distance identical, but only with the previous approval of the Engineer. In this case, the identity of soil conditions has to be proven by trial pits and soundings executed to such a depth that clear information about the bearing layer is obtained. This procedure is also subject to the previous approval of the Engineer.

For all locations, the contractor shall give clear information, in addition to the boring results for the following local conditions:

- soil conditions at the surface
- inclination of the ground in the area of the future foundations
- inclination of cracks and fissures in the rock and their stratification and judgment about the global stability
- relevant inclination of the ground surface in the vicinity of the future tower foundations if sliding or rolling stone effects are possible for the selected locations
- if flooding or scour action possible around foundations during periods of heavy water flow
- data about the max. groundwater table for all tower sites.

For all bore hole investigation locations, the following is to be carried out:

- bore holes down to min. 15 m, but min. 3 m below the intended base level of the piles and / or 5 m below the planning base of block foundations or of the bearing soil
- for rocky areas, the depth of drillings as above. Every shortening of the drilling depth is subject to the previous approval of the Engineer.

4.8.3.3.1. Execution of Borings

For the drilling in non-cohesive soil, the Contractor shall supply a bore equipment with a diameter of at least 150 mm. The equipment shall allow the additional execution of Standard Penetration Test (SPT) and undisturbed sampling for instance by using piston samplers. During boring, in case hard rock is met with, rock drilling shall be continued for a further depth of 5 m to establish continuity of rock strata. For special foundation locations a further depth of 5 m shall be used.

For drilling work in hard rocky soils a double tube core barrel of at least 7.5 cm inside diameter shall be used exclusively, provided that this kind of boring can be continued to the final bottom of the bore hole in question. A 95% core recovery will be required.

Beyond this, the Contractor may choose for his own convenience the type of equipment and accessories to be used at each individual bore hole and depth, provided that in the Engineer's opinion the equipment chosen is suitable for the drilling. The Contractor may also choose the initial and intermediate diameters of each bore hole for his own convenience, provided that he will secure the before mentioned minimum acceptable size of core.



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

Adequate casing has to be used to ensure the stability of the bore hole. The Contractor will not be entitled to any compensation or additional payment for casing.

The method of drilling, casing and flushing is to be described in the bid.

It is to be emphasized that the Contractor shall supply equipment to take undisturbed samples from cohesive and non-cohesive soils for laboratory tests, according to international standards.

4.8.3.3.2. Sampling

Undisturbed samples shall be of 100 mm diameter and 450 mm length. Samples shall be collected in such a manner that the structure of the soil and its moisture content are not changed.

Disturbed soil samples shall be collected in bore holes at regular intervals. Jar samples weighing approximately 1 kg shall be collected in bore holes at 0.5 m intervals starting from a depth of 0.5 m below ground level and at every identifiable change of strata to supplement the boring records.

Relevant storing has to be ensured. Non-cohesive soils have to be kept in water-tight boxes. Bore hole number and depth of sample shall be written on the cover of the bags and boxes. It must be ensured that the cores are placed in the boxes in the order as taken. Continuously the corresponding depth of the material shall be written on the partition walls of the boxes. Colored photographs of the said boxed samples are to be included in the final report.

The borders between different strata and sections of core loss shall be fixed with thin boards and marked with the depth. The core boxes shall be designed for approximately 7 meters of continuous soil samples. The boxes shall be accessible at each time for the Engineer. Ground-water and disturbed soil samples taken for the chemical analysis shall be kept in watertight, durable plastic jars.

4.8.3.3.3. Bore Logs

Detailed bore logs/field books must be kept for all borings. They shall include all pertinent data and results and all observations, measurements or tests as directed by the Engineer. The bore logs/field books have to be submitted within 3 days after completion of each bore hole.

4.8.3.3.4. Standard Penetration Tests

In all bore holes Standard Penetration Tests shall be performed from the cleaned bottom of the bore holes down to 45 cm below. Standard Penetration Tests shall be carried out at 1.0 m intervals and at every change in strata. The number of blows required to drive the sound each 15 cm into the soil has to be counted and kept in the bore log. The samples obtained from the Standard Penetration Tests shall be marked and kept in watertight bags in core boxes.

4.8.3.3.5. Test Pits

The Contractor shall excavate test pits for soil investigations, taking disturbed and undisturbed samples. The test pits shall be excavated in sedimentary and weakly cemented soils, where and as directed by the Engineer. The program for the test pits shall be arranged at site, depending on the results of the first investigations.

The test pits shall have a bottom width of at least 80 cm. The maximum depth will not be more than four meters. Excavation below groundwater shall be excluded. The Contractor will be responsible for keeping the pits in a state guaranteeing the stability of the walls and permitting inspection of the bottom and the walls at all time until starting of foundation work, or acceptance by the Engineer.

All protection of the pits shall be provided by the Contractor to prevent accidents. The Contractor shall take samples where and as directed by the Engineer and shall keep them in watertight bags or boxes. After the completion of the investigations, the Contractor shall refill the pits as directed.

4.8.3.3.6. Laboratory Tests



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

The Contractor shall order Laboratory Tests to determine the necessary soil mechanic parameters for the foundation design of towers. The kind and number of tests to be proposed by the Contractor – depending on the encountered soils and in view of his foundation design – will be approved by the Engineer during the field work according to the results of the borings.

The parameters to be determined are:

- Grain Size Distribution by Sieving and/or by Sieving and Sedimentation,
- Atterberg Limits,
- Natural Water Content,
- Specific Gravity,
- Dry Unit Weight,
- Unit Weight and Natural State and Water Content,
- Tri-axial Shear Test (three circles),
- Direct Shear Test (three points),
- Consolidation Test,
- Unconfined Compressive Strength (cylinder),
- Density Index
- Aggressiveness of soil and Water to Concrete.

The tests are to be carried out in conformity with international standards by a well experimented Institute to be named by the Contractor and approved by the Engineer. Other standards are subject to the Engineer's approval prior to the performance of the laboratory tests

The test results shall be submitted in a written test report.

4.8.3.3.7. Change of Investigation Program

It is understood and expressly agreed that the above given investigation program is only guideline and such in no way defines or limits the methods, the sequence of the work, the characteristics of the various working phases, as will be actually required in the Engineer's opinion in order to obtain the best results of the exploratory work.

The above program is purely indicative and subject to any alteration which will deem desirable on the basis of intermediate information obtained in the course of work. The Contractor shall conform to any directions issued by the Engineer concerning the amendment of the above program, no matter how extensive this amendment may be and he shall perform this work as directed by the Engineer.

4.8.3.4. Reports

Field reports have to be handed over to the Engineer at site including bore-logs with all pertinent data, Standard Penetration Tests results, ground water locations, core penetration diagrams, test pit logs as well as readings within three days after completion of the corresponding work.

On completion of all field laboratory work, the Contractor shall submit to the Engineer a Geotechnical Investigation report containing the procedure used during the investigation, field test results, laboratory observations and test results both in tabular and graphical form, practical and theoretical considerations for the interpretation of the test results, supporting calculations for the



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

conclusions drawn etc. The report shall contain theoretical as well as practical considerations for the design and construction of the foundations for different types of structures and any proposals which the Contractor may consider necessary to make with regard to the parameters and dimensions for the design of standard foundations and of special foundations.

The Contractors qualified geotechnical engineer shall visit the Engineer's office for a detailed discussion on the draft report. During the discussions, it shall be decided on the amendments that need to be made in the draft report. Thereafter, the Contractor shall incorporate in the report the agreed modifications and after the Employer approves the report, the Contractor shall submit ten (10) copies of the final report along with a reproducible set of all tables, graphs etc.

4.8.4. Earth works

4.8.4.1. General

The Contractor shall satisfy himself as to the ground conditions on the site including the nature of the strata to be excavated, obstructions, possibilities of flooding and such like and shall allow for all provisions necessary to carry out the work in the most suitable manner when submitting his Bid.

The Contractor shall excavate earth, rock, stumps and all other materials encountered as required for construction of tower foundations or as directed by the Engineer. The Contractor shall place all suitable excavated material in backfill or in graded embankment in the immediate area at structures, as directed. Materials found to be unsuitable for foundation backfill or grading shall be wasted and disposed of as directed by the Engineer.

Excavations shall be maintained in a clean, safe and sound condition until completion of the foundation construction. Suitable pumping equipment shall be provided and used to drain excavations where necessary so that where practical all installation work and backfilling is performed under dry conditions. Any previously prepared foundation bearing surface that is softened by water runoff or otherwise contaminated before placement of the tower foundation shall be excavated and replaced as directed by the Engineer at no extra cost to the Employer.

There will be no classification of excavated materials and the term "excavation" shall include all materials excavated or removed on the site or sites of the work regardless of the type, character, composition or conditions of the material excavated and shall further include all debris, junk, broken concrete, bricks, logs, stumps, roots and all other material encountered within the specified excavation limits.

The Contractor is responsible for all necessary safety measures. He is liable for any damage and accidents occurring while earth work is being carried out. Proper standing, including any necessary re-arrangement protection of slopes or cribbing, preparation of design calculations, etc. shall be deemed included in the prices.

4.8.4.2. Fill materials

The fill materials used are to be examined and approved. Excavated materials can be used if they fulfill the requirements.



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

4.8.4.3. Preparation of foundations

All kind of soils including rock surfaces on which or against which concrete is to be poured shall be carefully cleaned and roughened to the Engineer's satisfaction.

No concrete is to be poured until the foundation site is inspected and approved by the Engineer.

4.8.4.4. Backfilling

Foundations shall be backfilled with approved material compacted in layers by suitable equipment until optimum stability has been obtained to the satisfaction of the Engineer. Compacting shall be carried out with special care by means of pneumatic or mechanical rollers or other compactors of a type previously approved by the Engineer.

The thickness of fill layers, number of passes and type of equipment to be used shall be proposed to the Engineer after compaction tests have been made.

Backfilling of foundation work with approved materials shall be carried out only after foundations have been inspected by the Engineer.

4.8.4.5. Blasting

The Contractor shall not obtain or make use of any explosives without the express permission in writing by the Engineer.

The Contractor shall comply strictly with the regulation as required by the authorities regarding purchase, storage, issuance and use of explosives and transport of same to and from site and shall be deemed to have included in his Bid all costs arising from the use, storage and transport of explosives as well as from supervision of blasting by security forces.

The Contractor shall be insured with an approved insurance against all claims with respect to damage and injury arising from blasting.

Fuses, detonators or blasting caps shall not be transported or stored together with dynamite or other explosives. The location and design of the storage places, the transportation methods and the precautions that shall be taken to prevent accidents shall be subject to the Engineer's approval, but it is understood that this approval does not exempt the Contractor of his responsibility with regard to the handling of dynamite or other explosives.

Drilling and blasting plans shall be submitted well in advance for the Engineer's approval prior to commencement of any blasting work.

When blasting is carried out, trees, structures etc. in exposed position shall be adequately protected from damage.

4.8.4.6. Protection of existing utilities and services

During construction the Contractor shall provide all protection for existing utilities and services as may be required by his construction operations. Permanent protection of certain items shall be as included under other sections or as instructed by the Engineer.



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

4.8.4.7. Dust and mud control

The Contractor shall use all means necessary to control dust or mud on roads, construction areas and borrow pits.

Surfaces shall be regularly watered to prevent dust becoming a nuisance for the public and interfering with the proper execution of the works.

4.8.4.8. Draining during excavation

The Contractor shall furnish all materials and equipment and perform all work required for draining the foundation excavations required to permit construction of the foundations. The cost of draining is deemed to be included in the foundation rates.

During the placing of any concrete for the foundation, the water level in the excavation shall be kept below the base of the excavation.

4.8.5. Piling works (if necessary)

The work includes all work for the execution of piles as well as the work required for test piles, pile load tests and working piles (including logs and reports).

4.8.5.1. Scope of work

The piling work includes:

- The preparatory works, the installation of the working-site and all the temporary works requested for the piling
- The drilling of the piles using a temporary casing (bentonite or slurry drilling shall not be used)
- The steel reinforcement
- The concreting
- The grouting at the piles bases (if required)
- The cut-off
- The tests on the materials and the piles and any soil testing that the Contractor decides to perform for the works
- The inventory of fixtures, its costs and the costs resulting from the eventually damages caused by the piles execution, the Contractor is fully responsible for all the damages to any buildings or constructions resulting from the piling
- The cleaning of the working site, including the evacuation of any debris, temporary backfill, soil produced by the piling.

4.8.5.2. Documents to be submitted

The following documents shall be submitted by the Contractor to the Engineer in due time and are to be approved before starting the piling works:



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

- references concerning pile foundations carried out by the Contractor for similar structures and soil conditions, list of qualified staff
- detailed descriptions of the plant, equipment, materials and procedures proposed for every type of piling operations that is to be undertaken; these descriptions will include plant and equipment specifications, pile constructions sequence, protective systems, detailed construction or installation procedures, tests procedures
- a proposal of piles record book and pile record sheets
- piles drawings and calculations notices of the piles with the following information
- number and location of the piles
- working loads acting on the piles
- bearing pressures, settlements, horizontal displacements of the piles (isolated pile and groups of piles)
- the "useful" length of the piles with cut-off level and base level
- diameters of the piles
- steel reinforcements of the piles
- a general planning of the piling works

4.8.5.3. Pile prices

The lump sum price includes the mobilization/demobilization of all equipment, the setting up on each pile location and the actual execution of the piles (including boring, installation of the steel reinforcement with embedded length in the raft, anchorage in the rock/soil, supplying and installation of the concrete etc). the Contractor anticipate the execution of pile if the execution of piles is necessary due to particular site conditions. The price to is included in the BOQ price for foundations.

4.8.5.4. Rejection

If a pile is rejected by the Engineer, the Contractor has to replace it by others in the vicinity of the rejected pile on instruction of the Engineer and at no expense for the Engineer.

The Contractor shall bear the cost of:

- re-design of pile caps
- extra cost of construction involved due to unsatisfactory or incorrectly positioned piles.

4.8.6. Concrete works

4.8.6.1. Materials for concrete

All materials used for concrete and reinforced concrete structures shall be of the best quality, free from defects likely to undermine the strength and duration of service of the works. The materials furnished must at least comply with the agreed standards and with all requirements described in this specification.



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

The cement used for concrete, reinforced concrete, mortar, grout and plaster works shall be a moderate sulfate resisting Portland Cement.

The use of concrete additives shall be approved by the Engineer.

4.8.6.2. Concrete mixes

The mix proportions are to be determined by proper mix design based on the requirements for strength, workability and the particular site in which the concrete is to be placed. The mix design shall be carried out by the Contractor's Concrete Engineer and approved by the Engineer.

Minimum cube strength at 28 days in MPa	Maximum free water/cement ratio	Max. nominal aggregate size in mm	Min. cement content in Kg/m ³
20	0.40	20	300

4.8.6.3. Testing of fresh concrete by means of test cubes

All test cubes shall be made and tested for compressive strength in accordance with an approved test methods.

A minimum of 2 test cubes shall be made on each tower (from the same mix) and upon request from the Engineer.

If the results are less than those specified, the Engineer must suspend all concreting work and order further tests. Any concrete found not to comply with the specification shall be broken out and replaced to the satisfaction of the Engineer.

The Contractor shall pay all costs incurred in making, curing, delivering and testing of concrete cubes.

4.8.6.4. Transport of concrete

Immediately after mixing, the concrete shall be conveyed to the place of use as rapidly as possible using methods which will prevent the segregation, loss or contamination of materials. The concrete shall be placed and compacted within 90 minutes of the addition of water to the mix. Any concrete left unplaced after this time shall be rejected and removed from the site.

The concrete shall be transported in dumpers or trucks. Before using concrete pumps, placer pipelines, chutes or spouts it is necessary to have the written approval of the Engineer.

The Contractor shall obtain permission at least 24 hours in advance of any concrete pour.

4.8.6.5. Concreting operations

Inspection prior to concreting

All concreting methods shall be subject to the approval of the Engineer.

Concrete placing shall not be started until the Engineer has approved all preparation of forms, reinforcement, joints and all mixing, conveying, spreading, curing, finishing and protection equipment.



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

Placing of concrete

Concrete shall be placed in the forms as close as possible to its final position in a single operation to the full thickness of slabs, blocks and caps and shall be placed in horizontal layers, not exceeding 2.5 m height in a single pour in walls, columns and similar members.

The Contractor shall organize the pouring of concrete in such a manner that once concreting of a section has started the operation shall be continuous and each operation shall be completed prior to a stoppage.

The Temperature of concrete shall not exceed 30°C measured at discharge into the works.

Compaction and mechanical vibration of concrete

As concrete is being placed it shall be compacted by mechanical vibrators, to obtain a dense material free from honeycombing, free from water and air holes. The Contractor shall ensure that the vibrators are used in such a manner that the reinforcement is not displaced, the formwork not damaged and no segregation caused, but complete compaction of the concrete is achieved.

Finish of concrete

The concrete face shall have the finishes indicated on the drawings or in the present specification. The finished surface of the concrete shall be sound, solid and free from honeycombing, protuberances, air holes or exposed aggregate. No plastering, cement wash, mortar or paint shall be applied to cover defective concrete surfaces.

Concreting at night

When approval is given to carry out concreting operations (under control of the Engineer) at night or in places where daylight is excluded, the Contractor has to provide adequate lighting at all points of mixing, transportation and placing of concrete.

Repair of damaged or defective concrete

Concrete which has completed its final setting shall be inspected by the Engineer and any cracks, honeycomb areas, segregations, etc. shall be marked. No repairs shall be carried out until directed by the Engineer.

4.8.6.6. Formwork

The formwork and the supporting structure are to be so dimensioned as to be able to withstand all vertical and horizontal forces safely.

Supporting structures shall be sufficiently rigid to maintain the forms in their correct position and to be true to shape and dimensions so that the final concrete is within the limits of the dimensional tolerances specified in section "Dimensional Tolerances" herein.

Joints shall be sufficiently tight to prevent the leakage of cement grout.

4.8.6.7. Reinforcing steel

Reinforcing steel used in reinforced concrete shall comply with an approved standard submitted by the Contractor.

In order to ensure due progress of the works, the Contractor shall at all times maintain on the site a stock of reinforcing steel sufficient for the following month's work. No reinforcing steel shall be used upon the works until it has been accepted, as satisfactory by the Engineer.



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

The Engineer will reject any reinforcement steel as the result of any failed test therefore not withstanding the manufacturers or coating applicator's certificates.

The Contractor shall remove all rejected reinforcing steel from the site without delay at his own expense.

4.8.7. Foundation Orientation

The Contractor shall assume full responsibility for the accuracy of the exact location and orientation of each tower foundation. If not specified, the foundation orientation of each tower shall be placed in such a manner that the position of the longitudinal axis of the tower crossarm will lie:

- in a plane perpendicular to the traverse of the line for the foundation of each tower in a straight line section.
- in a plane bisecting the interior angle formed by the intersection of the adjacent line traverses for the foundations of each angle towers.
- in a plane perpendicular to the traverse of the line route (regardless of the traverse of the slack span) for foundations of each dead end tower except where otherwise indicated on the drawing(s).

4.8.8. Grounding

4.8.8.1. General

All towers shall be permanently and effectively grounded. After installation of the earthing system, the earthing resistance test shall be carried out by a method approved by the Engineer.

The individual tower footing resistance shall be less than 15 Ohms. In some areas tower footing resistance higher than 15 Ohms can occur, in such cases the Contractor shall propose an improvement method. The measurement shall be executed with equipments certified in an approved laboratory.

Individual tower grounding shall be made with ground rods or, when this is not possible, with radiating counterpoise wire, in accordance with the Specification.

All grounding material shall be standard commercial quality suitable for the intended use unless specified hereunder.

Before commencement of stringing, footing resistance measurements to be approved by the Engineer shall be made at each location; otherwise, the earth wire shall be disconnected.

4.8.8.2. Ground Connecting Wire

The ground connecting wire shall be 50 mm² section annealed copper wire.

4.8.8.3. Connections

- Ground Connection on towers

The connector shall be made of copper alloy and shall be complete with silicon bronze bolt, nut and lock washer. The bolt shall be of sufficient length to grip steel angle and lock washer.



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

Bi-metallic washers (copper / aluminum) shall be installed between the copper connectors and the tower.

- Compression Type Connector

The compression type connector may be used for ground connecting wire and/or counterpoise wire connection. The connector shall be made of copper alloy. The current carrying capacity of the connector shall not be less than that of ground connecting wire and/or counterpoise wire. The effective length of the clamp shall be sufficient to grip the connecting wires firmly under normal service condition.

4.8.8.4. Marking

All components except wire shall be clearly marked by means of legible relief process or impress process into the metal mold or die designated by the manufacturer and approved on the drawings. Marking for ferrous metal shall be done before galvanizing.

4.8.8.5. Data and Drawing

Detail drawings of all components shall include the following information

- Dimensions and tolerance
- Material details
- Catalog and marking number

4.8.9. **Protection against truck impacts**

In areas adjacent to main roads, the tower and tower foundations have to be protected against truck impacts by guard rails. The guard rail has to be installed 10m in front of the tower at the road side and at a certain length to the side in order to protect the other two tower faces.

4.8.10. **Foundation tests**

4.8.10.1. Verification of stubs orientation

- The distance between stubs tops and tower axes shall not differ more than 5mm per linear meter with a maximum of 10 mm.
- The stubs must be sloped accordingly with execution drawings. The difference shall not exceed 10 mm per meter.
- The maximum divergence between the levels of the stubs top shall not exceed 5mm.

4.8.10.2. Verification of foundations

The tests of foundations shall be conducted according to IEC 61773.

4.8.10.3. Pile Tests (if necessary)

The Contractor is requested to include his price for test piles and testing of piles in the erection price of his bid.



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

Prior to piling commencement the Contractor shall install two test piles of each type proposed. The piles shall be test-loaded by:

- tension, compression and horizontal forces
- axial load tension / compression applied along the stub-angle (tower leg).

The piles shall be considered as acceptable in case the obtained load settlement / heave-diagrams do not indicate movements beyond permissible limits as per Technical Specifications or the relevant standards. It is to the discretion of the Engineer to test any pile up to destruction. All test piles shall be removed.

Other (working) piles shall not be installed until the load tests have been conducted and the results evaluated.

4.9. Steel Tower Erection

4.9.1. Handling and storage

Care shall be taken during handling and storage to prevent tower injury to members or damage to galvanization or other protective surfaces. No steelwork shall be dragged over the ground surface or handled in such a manner as to damage the galvanized surfaces. Throwing of tower steel into piles on conveyances, onto the ground, or skidding of steel members over each other is not permitted.

All superficial rust stains, corrosive salts and other foreign materials deposited prior to or during installation of the towers shall be removed without causing damage to the protective surfaces.

In addition, any foreign material that will tend to adhere permanently to the towers shall be removed.

4.9.2. Tower erection

4.9.2.1. Erection procedures

The Contractor must ensure that tower erection and steel handling procedures and equipment shall be such as to ensure all person maximum safety.

The erection of tower shall start minimum 15 days after the pouring of concrete.

The towers may be erected by assembling tower sections on the ground and hoisting successive sections into place or they may be built-up in place by individual members.

If the Contractor's proposed tower erection method is to assemble the tower or portions thereof on the ground and raise this to the vertical position, this shall be taken into account during design and detailing of the towers and foundations. If the towers are erected by assembly in sections, initial bolting shall be adequate for all loads and erection stresses, but also to allow alignment.

When in position, all bolts or studding shall project completely through the corresponding nuts.

Proper precautions shall be taken to ensure that no parts of the towers are unduly stressed or damaged in any way during erection. A reasonable amount of drifting will be allowed in assembling towers, but reaming for correction of mismatched holes due to manufacturing errors will not be permitted.

Tower members arriving on site with distortions due to handling in transit, shall be straightened or replaced by the Contractor.



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

Suitable ladders shall be used whenever necessary during erection, but such ladders and removable step bolts shall be removed when erection work is not in progress.

Before assembly of members, joints/surfaces shall be free of all earth, or any other substance which might prevent the correct alignment of members.

After erection all towers shall be cleaned of all foreign matter or surplus paint.

Suspension towers shall be vertical after stringing with a tolerance of 1:300 at the apex related to the tower's actual height.

Angle-tension and terminal towers shall be suitably raked and/or so erected that after stringing a maximum tolerance of 1:300 at the apex related to the tower's actual height is allowed in the direction of the permanent load.

The Contractor shall submit erection procedure for approval at least one month before structure erection is scheduled.

4.9.2.2. Bolt tightening

All bolts shall be fitted with a spring lock washer. The spring washer shall be in addition to a normal flat washer if necessary to ensure that the bolt threads are excluded from the joint as specified.

After the complete tower is erected, the bolts shall be tightened to an approved torque and as indicated in the following table:

Size of Bolts (mm)	Tightening Torque (Nm)
12	60 ... 80
16	100 ... 120
20	140 ... 180
24	310 ... 370

Spanners used during erection shall be well shaped and fit closely on the nut to avoid damaging nuts and bolt heads.

After torquing, all nuts below the anti-climbing device shall be locked in place with locknuts or by deforming the thread in an approved manner. The bolts shall be installed in such a way that locknuts and nuts are in the "Up" or "Out" position. The nuts and locknuts shall run freely (i.e. hand fit) for the center length of the bolt thread.

4.9.2.3. Faulty members

If shop errors in the steel members are discovered, the Contractor shall notify the Engineer who will decide whether the errors may be corrected in the field, or the members have to be returned to the manufacturer for correction or replacement.

4.9.2.4. Damaged members

Members that are bent, twisted or otherwise deformed in storage, transportation, handling or erecting operations shall be straightened or replaced by the Contractor. Straightening shall be done only by the use of methods that will not damage the zinc coating. Tolerances for lateral variations of straightened members shall be as follows:



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

Member Type	Tolerances
Compression Members	± 2 mm/1000 mm
Tension-only Members	± 6 mm/1000 mm

Members that are damaged in a manner causing reduction in their strength shall be replaced at the Contractor's expense.

4.9.3. Damaged Galvanizing

All galvanizing damages as a result of transportation, handling, storage, repair operations of deformed or bent members, field drilling or installing shall be repaired by the Contractor. The damage area shall be cleaned by wiping with clean rags saturated with mineral spirits of xylene followed by wire brushing. After wire brushing, the area shall be re-clined with solvent to remove residue and shall be given a minimum of two coats of an approved galvanizing repair paint.

The percentage of pure zinc by weight in dry film of galvanizing repair paint shall not be less than 85.

If damage to galvanized coating of members can not be repaired at the site, the Contractor shall re-galvanize the damage member at manufacturer's factory or in other place accepted by the Employer.

4.9.4. Tower Signs

The Contractor shall install the signalization and danger signs on each tower on legs designated by The Engineer at a height about 4 m above the ground level. Detailed drawing shall be submitted to the Engineer for approval.

Aerial plates shall be installed every ten towers and on important angle towers.

4.9.5. Painting of the top Part of Towers

4.9.5.1. Inspection and warranty

The materials and equipment used, the methods of application and the quality of work shall at all times be subject to the inspection and approval of the Engineer.

To provide proof of warranty, various identified and recorded test patches shall be applied.

Defects which affect the corrosion protection and which are caused either by inadequate workmanship of application or by the coating material must be rectified by the Contractor at his cost.

4.9.5.2. Weather conditions

Painting shall only be done when no condensation occurs on the surface. Therefore relative humidity shall be checked.

Painting of outdoor parts etc. is not allowed immediately prior and during heavy windy, rainy or dusty conditions.

In hot weather precautions shall be taken to ensure that the specified dry film thickness of priming or finish coats is obtained.



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

Any prime coat exposed to excess humidity, rain, etc., before drying shall be permitted to dry and the damaged area of primer removed and the surface prepared and primed again.

4.9.5.3. Surface preparation

Surface preparation should remove sufficient foreign matter to allow the type of prime paint used to wet the surface thoroughly and develop adequate adhesion.

In preparing any surface to be coated, all loose paint, dirt, grease, rust, scale, weld slag or spatter or any other extraneous material shall be removed and defects repaired, so as to obtain a clean, dry, even surface to receive the priming or finishing coat(s) as called for in the painting schedules. Sharp edges should be rounded.

All machined surfaces including flange faces shall be suitably covered to prevent damage during surface preparation.

4.9.5.4. Preparation of coating materials

Primers and paints which have gelled or are otherwise deteriorated shall not be used. All ingredients in any container shall be thoroughly mixed before use and shall be agitated frequently during application to keep the primer in suspension.

Primer or paint mixed in the original container shall not be transferred until all settled pigment is incorporated into the body of liquid. Primer or paint shall be mixed in a manner ensuring the breakdown of all lumps, complete dispersion of pigment and uniform composition.

Thinners shall not be added to primers or paints unless necessary for proper application according to the manufacturer's instructions.

The type of thinners used shall comply with the manufacturer's instructions. When use of thinners is permitted, it shall be added to the primer or paint during mixing in a good ventilated area.

4.9.5.5. Application

All prime coatings shall be applied by brush or airless spray or a combination of these methods, as approved by the coating manufacturer.

Spray guns should not be used outside in windy weather or near surfaces of a contrasting color unless the latter is properly protected from the spray. All cold-spray painting shall be done using standard equipment in accordance with accepted industry standards and methods.

Paint misplaced on items that are not to be painted shall be removed on demand of the Engineer at the Contractor's expense, leaving the surface clean, unstained and undamaged.

To the maximum extent practicable, the coats shall be applied as a continuous film of uniform thickness and free of pores. Overspray, skips, runs, sags and drips should be avoided. The different coats shall not be of the same color.

Each coat of paint shall be allowed to harden before the next is applied. For epoxy paint the hardening time before the next coat shall normally be 12 to 14 hours. Suppliers' recommendations regarding hardening time of epoxy paints shall be observed.

Particular attention shall be paid to full film thickness at edges.



4.9.5.6. Red/white tower painting

All the tops of the towers shall be painted in red and white bands. Detailed method and drawings shall be submitted by the Contractor.

4.10. Installation of conductor and OPGW

4.10.1. Generality on conductors and OPGW stringing

The stringing activities shall be executed in accordance with IEC 61328.

4.10.1.1. Handling and storage

In storage and during handling, all conductor and OPGW reels shall be kept clear off the ground and in clean conditions. Contact with any substances likely to damage the materials and reels shall be avoided.

The Contractor shall take adequate precautions during handling, storage and installation to prevent kinking, twisting, nicking or other damage to the materials and reels. The conductors and OPGW shall never be dragged over the ground or any other rough surface.

Suitable precautions shall be taken to avoid that the reels will drop down when loading and unloading from vehicles.

4.10.1.2. Stringing plan

At least two months before stringing starts the Contractor shall give due consideration to all the factors involved and shall submit to the Engineer for approval a fully detailed stringing schedule stating the following indications:

- The locations of conductor and earth wire drums and pullers
- the proposed position of mid-span joints,
- the maximum tensions to be used during running out of pilot wires, conductors and OPGW,
- the sag of each span
- The crossing of roads, rivers
- The crossing and proximity of overhead lines (with their definitive outage requests)
- Protection of important crossings

4.10.1.3. Crossing of roads, power lines etc.

Scaffoldings or cranes shall be provided over roads, power and communication lines, houses etc.

When the Contractor is about to carry out erection of the conductors or OPGW along or across power lines or telecommunication lines, public roads, he shall be responsible for giving requisite notice to the appropriate authorities of the date and time at which he proposes to carry out the work.

Scaffolding or cranes shall be used to prevent the conductor and OPGW from coming within 5 meters of roads and 2 meters from telecommunication lines and power lines during unreeling.



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

The scaffolding itself shall also have the aforementioned clearances. Efficient temporary grounding shall be installed in case metal scaffoldings are used for power line crossings. The scaffoldings shall be sufficiently long to cater for any conductor side-swing which may occur during stringing and shall be of sufficient strength to withstand wind pressure, vertical loads and all other loads which may be anticipated.

The cost of all scaffolding shall be included in the stringing price.

The Contractor shall at his own expense make the necessary arrangements and take the necessary precautions where the route crosses swamp, or streams, other obstacles or grounds over which erection cannot be carried out in the normal manner.

4.10.1.4. Tools and equipment

4.10.1.4.1. Snatch Block

Snatch-blocks shall be designed especially for stringing the conductors and shall have grooves of a shape and size in accordance with the requirements of IEEE Standard 524. The sheaves shall be equipped with high quality ball or roller bearings. The sheaves shall be lined with bonded neoprene or equivalent rubber material approved by the Engineer. The sheaves used for installation of galvanized steel stranded overhead ground wire may be unlined. Unlined sheaves, if employed, shall be made of aluminum magnesium alloy and the grooves shall have a smooth, polished finish.

The sheaves shall have free and easy movement in the blocks and shall cause no damage to the cable contact surface. Sheaves which do not run freely or which hinder the stringing operation shall be immediately replaced.

4.10.1.4.2. Reel Stands

Reel stands shall be strongly constructed and reel brakes shall be provided. Braking of the conductor and OPGW reels during stringing shall be positively controlled and shall be applied in a manner which will avoid damage to the conductor or OPGW or to the reels.

4.10.1.4.3. Pilot Wire

Pilot wires shall be made of non-twist steel wire. The pilot wire shall be strong enough for stringing work.

4.10.1.4.4. Powered Puller

The powered puller shall have a capacity of not less than the maximum stringing tension of the conductor and OPGW. The puller system shall have a powered winch with transmission gears for changing speed during stringing work.

4.10.1.4.5. Tension stringing equipment

Tension stringing equipment shall be of neoprene or Teflon lined bull wheel-type. The bull wheel brake or brake control shall be designed such that when the maximum tension is obtained, the tension will be held constant so long as the brakes are left at this setting. The bull wheel diameter and lining material shall be approved by the Engineer. A neoprene or Teflon lining material at least 6 mm thick would be acceptable.

4.10.1.4.6. Come-along

Come-alongs shall be of the type that can be installed anywhere on the conductor and grips it more firmly as the tension of the conductor increases. Any other type of come-along, if employed, shall be subject to approval by the Engineer.

4.10.1.4.7. Compressors for Joints and Dead End Connector Assemblies



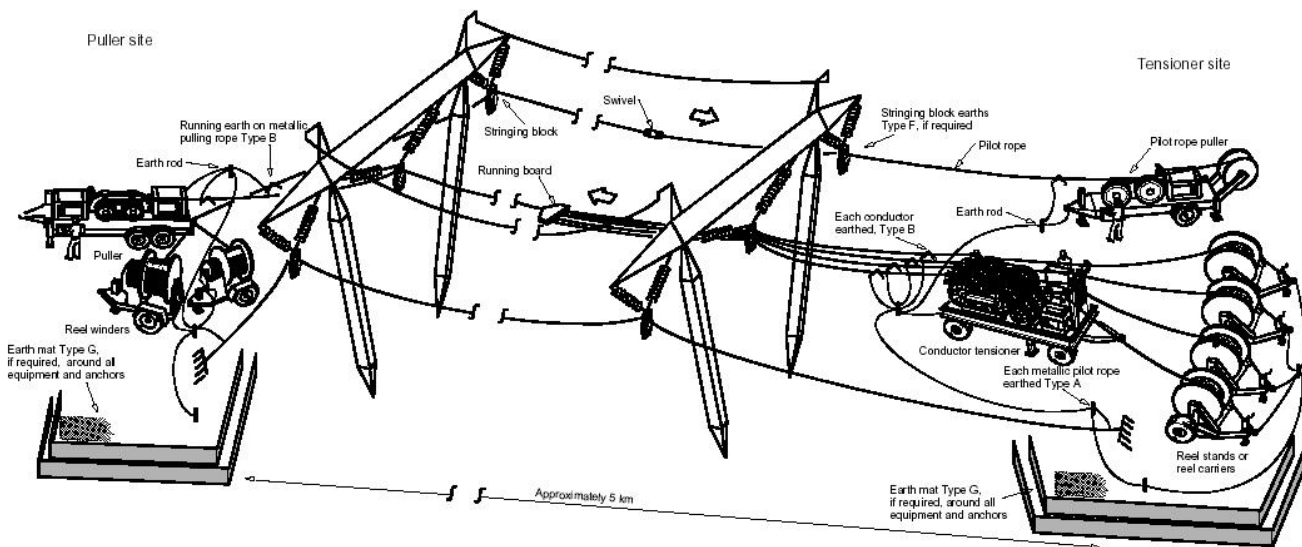
Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

Suitable hydraulic compressors equipped with pressure gauges and dies or other approved types shall be used for tension joints and compression dead-end connections. This shall thoroughly satisfy the requirements for jointing of the conductor.

4.10.1.4.8. Length meter

A length meter for measuring the conductor or OPGW during stringing shall be provided and may be part of either the powered puller or the tension stringing equipment.



Tension stringing method

4.10.2. Line hardware and insulator assembly installation

Insulators and fittings shall remain in their crates and shall be removed only just prior to erection and shall be handled carefully to avoid damage.

Insulators shall be cleaned immediately prior to lifting onto structures with a soft cloth to remove all dust and deposits. Abrasives or wire brushes shall not be used.

Lifting shall be done with approved cradles or slings to avoid damage.

4.10.3. Stringing OPGW

OPGW shall be strung for the entire length of the transmission line and shall be attached to the structures in accordance with the details shown on the drawings. The methods used for OPGW stringing shall be the same as for the conductors, except for the differences stated in this clause.

OPGW shall be kept off the ground at all times when the OPGW is in motion. The method of tension stringing required for installation of all OPGW shall be continuously controlled.

The Contractor shall take special care that the OPGW are not dragged on the ground at any time during erection or come into contact with any obstacles such as walls, fences or buildings, etc.



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

OPGW drums shall be closely examined before pulling commences and all nails and other things, which could damage the OPGW, shall be removed. During stringing, the OPGW drums are to be supervised at all times and the OPGW shall be inspected for defects whilst it is being pulled off the drum. Watchmen shall also be positioned at critical structure locations to ensure a smooth stringing operation.

The OPGW tension during stringing operations shall be kept as low as possible, consistent with keeping the conductor a safe distance clear off the ground whilst in motion.

All stringing equipment shall be properly anchored and shall be positioned in such a way that towers and fittings will not be overloaded. OPGW reels shall be securely anchored during stringing operations and reel jacks shall be of the self braking type to prevent OPGW over run. OPGW pulling equipment is to be such as will ensure a continuous steady pull. Every precaution is to be taken to prevent damage to the OPGW. Clamps and other devices used for handling the OPGW during erection shall allow no slippage or relative movement of strands or layers and shall not pinch or deform the OPGW.

Vibration dampers shall be installed on the OPGW based on the manufacturer's recommendation and as approved by the Engineer.

4.10.4. Stringing conductors

Conductor stringing shall be carried out entirely by tension stringing methods and the Contractor shall submit for approval full details of the precise method of tension stringing and of the stringing equipment he intends to use. Conductors shall be kept off the ground at all times when the conductor is in motion. The method of tension stringing required for installation of all conductors shall be continuously controlled.

The four conductors forming the bundle of each phase shall be installed at the same time and shall be maintained at the same tensions throughout the operation.

Stringing of conductors shall, in no case, be performed until 28 days after foundation concrete has been placed or such other time approved by the Engineer depending upon the type of concrete used and local conditions and not until assembly and tightening of bolts of structures have been completed and inspected by the Engineer.

Maximum use shall be made of the full conductor lengths in order to reduce the number of joints to a minimum. The number and location of conductor midspan joints shall be approved. Midspan joints shall not be less than 30 m from the nearest conductor clamp.

The Contractor shall take special care that the conductors are not dragged on the ground at any time during erection or come into contact with any obstacles such as walls, fences or buildings, etc.

Conductor drums shall be closely examined before pulling commences and all nails and other things, which could damage the conductor, shall be removed. During stringing, the conductor drums are to be supervised at all times and the conductor shall be inspected for defects whilst it is being pulled off the drum. Watchmen shall also be positioned at critical structure locations to ensure a smooth stringing operation.

All stringing equipment shall be properly anchored and shall be positioned in such a way that towers, insulators and fittings will not be overloaded. Conductor reels shall be securely anchored during stringing operations and reel jacks shall be of the self braking type to prevent conductor over run. Conductor pulling equipment is to be such as will ensure a continuous steady pull. Every precaution is to be taken to prevent damage to the conductor. Clamps and other devices used for handling the conductor during erection shall allow no slippage or relative movement of strands or layers and shall not pinch or deform the conductors.



4.10.5. Earthing of conductors, OPGW and stringing equipment

Conductors and OPGW shall be effectively earthed in an approved manner during running out at all places where men are working on them.

Sufficient earth to maintain safety shall be kept until the time of taking over. The position of each earth shall be recorded by the Contractor.

Conductor sheaves lined with neoprene or rubber shall have an electrical conducting path between their suspension points and the conductor or OPGW supported within them and shall run with minimum friction.

When stringing operations are being carried out in close proximity to or crossing energized lines, the Contractor shall take all precautions necessary to prevent accidents and injuries to persons and property due to induction or physical contact.

4.10.6. Repair of damaged conductors and OPGW

Any damage caused to a conductor or OPGW shall immediately be reported to the Engineer whose decision to replace or repair will be final.

Repair of the damage shall be carried out in the manner indicated or approved by the Engineer at the expense of the Contractor.

When damage to the conductor and OPGW does not exceed two aluminum strands, either broken or nicked deeper than one-third of their diameter, repair sleeves may be installed. When more than two strands are broken, abraded or nicked deeper than one-third of their diameter, the damaged section of the conductor shall be cut out and the OPGW shall be replaced.

When there is repeated damage on the same span or in consecutive spans, all the conductor and OPGW so affected in these spans shall be replaced.

All damage caused by come-along and other gripping devices shall be repaired or cut out, as required by the Engineer, before the conductor and OPGW are finally sagged.

Conductor and OPGW repair sleeves shall not be used without the permission of the Engineer and will be granted only in exceptional circumstances. No repair sleeves shall be used in spans crossing over power lines of voltages higher than 1 kV, telecommunication overhead lines and buildings as well as in single span sections. To permit handling without damage to the conductor and OPGW, the Contractor may be required to rewind on new drums.

Re-drumming because of damage by the Contractor shall be at the expense of the Contractor.

4.10.7. Jointing of conductors and OPGW

Joints in the conductors shall be of the compression type. Conductors shall be terminated at tension towers by means of compression type dead-end assemblies.

Joints of OPGW shall be of helical grip type. OPGW shall not be terminated at tension towers. They pass the tension towers and go into the next helical grip of the next section, until to the joint box.

Jointing of all conductors shall be performed as nearly as practicable at the same position. All compression joints shall be filled and finished with emery cloth to produce a smooth surface, free of flash and sharp points, which might be a source of corona or radio interference. The Contractor shall furnish all necessary tools, including compression tools required.

At joints and terminations, the contact surface of conductors, dead-ends, mid-span joints and jumper terminals, including the faces of contact palms, shall be bright and clean and shall be



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

liberally coated with Alcoa No. 2 Jointing Compound or an approved equivalent before compression and bolting operations are carried out.

The Contractor shall ensure that no bird-caging, over-tensioning of individual wires or layers or other deformation or damage to the conductor or OPGW occurs. Cutting of layers of conductors and OPGW shall be carried out with tools designed to prevent damage to underlying strands or optical fiber tubes.

The Contractor shall keep a record of each compression fitting showing its location, date of assembly and the name of the linesman responsible for the assembly.

Where records of the joints made by a particular linesman show a repeated performance below the required standard the Contractor shall, at the request of the Engineer, cease to employ him on jointing operations and immediately replace him with other qualified personnel and rectify the corresponding points at his own expense.

All conductor joints shall be located in the span at least 30 m away from a suspension clamp or tension clamp or compression dead-end. There shall be not more than one such joint per conductor in any one span.

Jointing shall not be permitted in a span between two adjacent tension towers and when crossing or adjoining the following objects: roads, power lines, telecommunication lines, buildings.

Jointing shall not be performed in rain or in the dark. To develop the rated mechanical strength and electrical conductivity, the installation of compression joints shall be carefully supervised to ensure that the joints are properly carried out.

4.10.8. Sagging

The conductors and OPGW shall be sagged in accordance with tension/sag tables calculated by the Contractor and approved by the Engineer from 0°C to 65 °C.

The Contractor shall submit stringing sag and tensions chart which shall be follows:

- -15 °C than the design sag and tension chart for aluminum cables
- -10° C than the design sag and tension chart for aluminum steel cables

The correct sag shall be determined by accurate sighting in the selected span or, in cases where sighting is considered unsatisfactory by the Engineer, another method approved by the Engineer shall be used.

The Contractor shall provide and use a reliable radio communication system to assist in the control of conductor and OPGW tensioning operation. The conductor/OPGW tensions shall not exceed the tensions determined from the stringing chart.

All conductor and OPGW sagging shall be performed during daylight hours. Sagging operations shall not be permitted during high wind, or other adverse weather conditions which would impair the accuracy of the sagging.

A sag tolerance of 3% will be tolerated but provided all conductors in the span assume the same sag and the necessary ground clearance is obtained.

The spans adjacent to gantries of Substations shall be slack spans.

Clearances between conductors and ground and between jumpers and all structures are to be checked during erection and before handing over the line.

The Contractor shall keep a schedule recording all sagging operations showing details of the section, the sagging and checking spans, ambient temperature, pre-stress (where appropriate)



Overhead Transmission Lines

General Technical Specifications– Overhead Transmission Line

initial and final sags, the date of sagging and clipping-in offsets. This record schedule along with the record of compression fittings shall form part of the final records for the line and shall be handed over to the Engineer. The records shall be available for inspection at any time.

OPGW installation shall be supervised by the fiber optic cable manufacturer's representative.

4.10.9. Clipping in

All conductors and OPGW shall be accurately marked for clipping-in at all towers on the same day following final sagging.

Clipping-in offsets shall be calculated by the Contractor and marked using a method approved by the Engineer that will not damage the conductors and OPGW.

Preformed armor rods shall be installed at all points of conductor and OPGW suspension. Armor rods shall be carefully centered in the suspension clamp. Suspension clamps shall be installed and adjusted such that the insulator string in its final position hangs in a vertical plane through the axis of the structure.

4.10.10. Vibration Protection Devices

The vibration protection devices, such as vibration dampers or anti-vibration jumpers, shall be installed in accordance with the manufacturer's recommendations and accepted by the engineer.

4.11. Clean-up

Completion of the work shall be immediately followed by clean-up of the work site. The Contractor shall remove the work, all plant, building, equipment, rubbish, concrete forms and other like materials from the vicinity. Unused materials shall be incinerated or disposed of at places which will not be unsightly or objectionable to the inhabitants of the area.



5. Line Testing

5.1. Final checking and testing

5.1.1. Final checking

Subsequent to the completion of the transmission line construction, the Contractor shall carry out final checking and testing works and shall provide to the Engineer:

- Tools, appliances and spare materials required for maintenance of the transmission line as detailed in the particular technical specifications.
- All outstanding drawings and documentation to be provided under the Contract.

The final checking shall include but not be limited to:

- Tightening of bolts and fixing of missing members to towers;
- Remove all scaffolds and equipment and clear all debris and other rubbish from the site;
- Restore surface damage, foundation subsidence and carry out erosion control measures, where directed by the Engineer or as required by local authorities or regulations;
- Remove all left-over materials at winch yards, drum yards and store yards;
- Complete danger tree clearing and tree re-clearing on the easement;
- Check phase sequence plates on both sides of all points of the line;
- Measurement of the OHTL parameters.

5.1.2. Line testing

Prior to the handover of the completed line, the following tests shall be carried out:

- Conductor electrical continuity proving tests for each phase, by an approved and witnessed method by the Engineer
- Insulation merger tests for each phase, witnessed by the Engineer;
- Tower earthing system electrical resistance measurements by means of a high frequency instrument supplied by the Contractor and approved by the Engineer
- OPGW performances, including OTDR tests.

5.2. Hand-over date

On completion of the final checking and testing, the Contractor shall deliver to the Engineer a written statement certifying that the line is complete in every respect and that all earths placed by the Contractor have been removed and that every member of the Contractor's staff has been informed that nobody is allowed to work on the line unless a working permit has been issued and signed by the Engineer.

