Q U E T T A   E L E C T R I C   S U P P L Y   C O M P A N Y   L I M I T E D

INTERNATIONAL COMPETITIVE BIDDING (ICB)

BIDDING DOCUMENT NO: IGM/NGS – LOT # IIIA
SINGLE STAGE - TWO ENVELOPE BIDDING PROCEDURE

FOR

PROCUREMENT OF PLANT-DESIGN, MANUFACTURE, SUPPLY AND CONSTRUCTION OF FOUNDATIONS, ERECTION OF TOWERS, INSTALLATION OF TRANSMISSION LINE CONDUCTOR, HARDWARE, ACCESSORIES, INSULATORS, STOCK BRIDGE DAMPERS, STRINGING, TESTING AND COMMISSIONING OF (COASTAL/NON-COASTAL AREAS) FOR

7. 132kV SDT T/L FROM 132kV GRID STATION TURBAT TO 132kV GRID STATION PANJGOOR
8. 132kV D/C T/L FROM 300MW POWER PLANT GWADAR TO 132kV GRID STATION TURBAT

WITH AASC “GREELEY’’ CONDUCTOR ON TURNKEY BASIS, FOR INTERCONNECTION OF ISOLATED GWADAR/MAKRAN AREA WITH NATIONAL GRID SYSTEM OF PAKISTAN.

VOLUME-2

DECEMBER – 2020

PROJECT DIRECTOR (GSC), QESCO QUETTA

CONSULTANT

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4	P-139:80	Suspension, Medium & Heavy angle Towers
5	P-162:81	Barbed Wire
6	P-104:76	Number, Danger and Sign Plates
7	P-20:68	Plain Steel Washers
8	P-166:83, IEC 60826(CAT:D), ASTM-572 & T.P	Steel Poles
9	P-8:96 & T.P	Disc Type Porcelain Insulators
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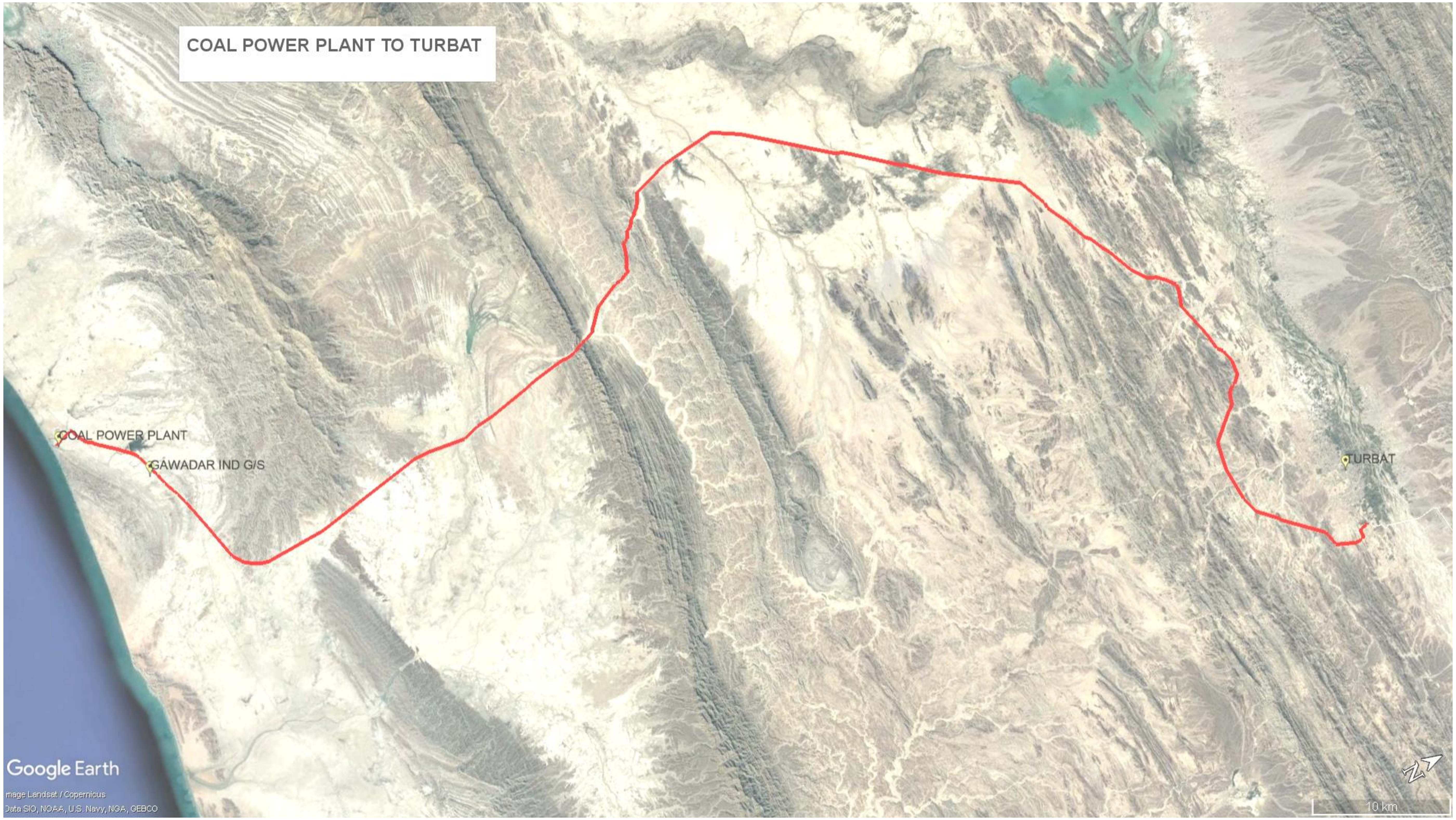
15	P-141:80 & T.P	Suspension Fittings, Tension Fittings & Mid Span Joint (For AWS)
16	P-16:68, P-116:81	Grounding Material

SECTION-01


COAL POWER PLANT TO TURBAT
COAL POWER PLANT
GAWADAR IND G/S
TURBAT
Google Earth
mage Landsat / Copernicus
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
10 km


TURBAT- PANJGOOR (SECTION-01)
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TURBAT- PANJGOOR (SECTION-02)
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20 km

SECTION-02

SCHEDULE OF TECHNICAL DATA

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1. DEVIATIONS FROM TECHNICAL PROVISIONS

Note: Attach additional sheets, if necessary. Non listing of deviations, if any, shall make the tender non-responsive.

Sr. No.	Clause No. of Technical Specifications	Variation	Remarks (Including Justification)

Signature and seal of the
Manufacturer/Bidder

Note:-

1. Bidders must recognize that substantial deviations may render the Bid substantially non responsive and subject to rejection.
2. Where there is no deviation, the statement should be returned duly signed with an endorsement indicating "No Deviations".

2. DEVIATIONS FROM CONTRACTUAL CONDITIONS

It is presumed that the bidder shall not take any deviation. However, if he intends to take deviations to the specified Contractual/Commercial Conditions, these must be listed in the space provided below:

Sr. No.	Clause No. / Section No.	Deviations/Clarifications

[Note: Attach additional sheets, if necessary]

Signature and seal of the
Manufacturer/Bidder

3. SCHEDULE OF TECHNICAL DATA FOR TOWERS ZM-1, ZM-30 & ZM-60

Sr.No	Description	Tower Type		
		ZM-1	**ZM-30**	**ZM-60**
1	Manufacturer's Name			
2	Ultimate Tensile Strength of the Steel Used			
3	Minimum Guaranteed Yield Strength of Steel Used			
4	**Minimum Elongation in 200mm Gauge Length:**			
	a- Upto 8mm Thickness			
	b- Over 8mm Thickness			
5	**Chemical Composition of The Steel Used:**			
	a- Carbon			
	b- Manganese			
	c-Phosphorous Max			
	d-Sulphur Max			
	e- Any Other			
6	Name of the Process of Making the Steel			
	Nuts and Bolts			
7	Type of Material of Nuts and Bolts			
8	Standard of Nuts and Bolts			
9	Size of Nuts and Bolts			
10	Type of Material for Washers			
11	Size of Washers			
	Marking			
12	Method of Marking of the Member			
13	Size of Letters for Marking			
	Tolerance			
14	Limit of Vertical Deviation after Erection, if applicable			
	Galvanizing			
15	Standard of Galvanizing Steel Sections			
16	Standard of Galvanizing Bolts and Nuts			
	Brittleness			
17	Standard of Checking embrittlement			
18	Estimated Weight of Towers Including Galvanization, Gusset Plates, Foundation Stubs, Nuts and Bolts			
	a- Tower type ZM-1			

	b- 3m Leg extension for Tower type ZM-1			
	c- 6m Leg extension for Tower type ZM-1			
	d- Tower type ZM-30			
	e- 3m Leg extension for Tower type ZM-30			
	f- Tower type ZM-60			
	g- 3m Leg extension for Tower type ZM-60			
19	The offered material is corrosion resistant to the atmospheric heavy pollution and at coastal areas			

Notes: 1) Bidder has to fill-up above details to verify the Technical Data of his proposed Manufacturer
2) All values shall be in metric system.

Signed and Stamp by the Manufacturer

Signed and Stamped by the Bidder

4. SCHEDULE OF TECHNICAL DATA FOR TOWERS ZM30-(M) & ZM60- (M)

Sr.No	Description	Tower Type	
		ZM30-(M)	ZM60-(M)
1	Manufacturer's Name		
2	Ultimate Tensile Strength of the Steel Used		
3	Minimum Guaranteed Yield Strength of Steel Used		
4	**Minimum Elongation in 200mm Gauge Length:**		
	a- Upto 8mm Thickness		
	b- Over 8mm Thickness		
5	**Chemical Composition of The Steel Used:**		
	a- Carbon		
	b- Manganese		
	c-Phosphorous Max		
	d-Sulphur Max		
	e- Any Other		
6	Name of the Process of Making the Steel		
	Nuts and Bolts		
7	Type of Material of Nuts and Bolts		
8	Standard of Nuts and Bolts		
9	Size of Nuts and Bolts		
10	Type of Material for Washers		
11	Size of Washers		
	Marking		
12	Method of Marking of the Member		
13	Size of Letters for Marking		
	Tolerance		
14	Limit of Vertical Deviation after Erection, if applicable		
	Galvanizing		
15	Standard of Galvanizing Steel Sections		
16	Standard of Galvanizing Bolts and Nuts		
	Brittleness		
17	Standard of Checking embrittlement		
18	Estimated Weight of Towers Including Galvanization, Gusset Plates, Foundation Stubs, Nuts and Bolts		
	a- Tower type ZM-30(M)		

	b- 3m Leg extension for Tower type ZM-30(M)		
	c- Tower type ZM-60(M)		
	d- 3m Leg extension for Tower type ZM-60(M)		
19	The offered material is corrosion resistant to the atmospheric heavy pollution and at coastal areas		

Notes: 1) Bidder has to fill-up above details to verify the Technical Data of his proposed Manufacturer
2) All values shall be in metric system.

Signed and Stamp by the Manufacturer

Signed and Stamped by the Bidder

5. SCHEDULE OF TECHNICAL DATA FOR TOWERS WPS, WPA & WPD

Sr.No	Description	Tower Type		
		WPS	WPA	WPD
1	Manufacturer's Name			
2	Ultimate Tensile Strength of the Steel Used			
3	Minimum Guaranteed Yield Strength of Steel Used			
4	**Minimum Elongation in 200mm Gauge Length:**			
	a- Upto 8mm Thickness			
	b- Over 8mm Thickness			
5	**Chemical Composition of The Steel Used:**			
	a- Carbon			
	b- Manganese			
	c-Phosphorous Max			
	d-Sulphur Max			
	e- Any Other			
6	Name of the Process of Making the Steel			
	Nuts and Bolts			
7	Type of Material of Nuts and Bolts			
8	Standard of Nuts and Bolts			
9	Size of Nuts and Bolts			
10	Type of Material for Washers			
11	Size of Washers			
	Marking			
12	Method of Marking of the Member			
13	Size of Letters for Marking			
	Tolerance			
14	Limit of Vertical Deviation after Erection, if applicable			
	Galvanizing			
15	Standard of Galvanizing Steel Sections			
16	Standard of Galvanizing Bolts and Nuts			
	Brittleness			
17	Standard of Checking embrittlement			
18	Estimated Weight of Towers Including Galvanization, Gusset Plates, Foundation			

	Stubs, Nuts and Bolts			
	a- Tower type WPS			
	b- 2m Leg extension(Single) for Tower type WPS			
	c- 4m Leg extension(Single) for Tower type WPS			
	d- 6m Leg extension(Single) for Tower type WPS			
	e- 8m Leg extension(Single) for Tower type WPS			
	f- -3m Body extension for Tower type WPS			
	g- Tower type WPA			
	h- 2m Leg extension(Single) for Tower type WPA			
	i- 4m Leg extension(Single) for Tower type WPA			
	j- 6m Leg extension(Single) for Tower type WPA			
	k- 8m Leg extension(Single) for Tower type WPA			
	l- Tower type WPD			
	m- 2m Leg extension(Single) for Tower type WPD			
	n- 4m Leg extension(Single) for Tower type WPD			
	o- 6m Leg extension(Single) for Tower type WPD			
	p- 8m Leg extension(Single) for Tower type WPD			
19	The offered material is corrosion resistant to the atmospheric heavy pollution and at coastal areas			

Notes: 1) Bidder has to fill-up above details to verify the Technical Data of his proposed Manufacturer

2) All values shall be in metric system.

Signed and Stamp by the Manufacturer

Signed and Stamped by the Bidder

6. SCHEDULE OF TECHNICAL DATA FOR TOWER EG

Sr.No	Description	Tower Type
		EG
1	Manufacturer's Name	
2	Ultimate Tensile Strength of the Steel Used	
3	Minimum Guaranteed Yield Strength of Steel Used	
4	**Minimum Elongation in 200mm Gauge Length:**	
	a- Upto 8mm Thickness	
	b- Over 8mm Thickness	
5	**Chemical Composition of The Steel Used:**	
	a- Carbon	
	b- Manganese	
	c-Phosphorous Max	
	d-Sulphur Max	
	e- Any Other	
6	Name of the Process of Making the Steel	
	Nuts and Bolts	
7	Type of Material of Nuts and Bolts	
8	Standard of Nuts and Bolts	
9	Size of Nuts and Bolts	
10	Type of Material for Washers	
11	Size of Washers	
	Marking	
12	Method of Marking of the Member	
13	Size of Letters for Marking	
	Tolerance	
14	Limit of Vertical Deviation after Erection, if applicable	
	Galvanizing	
15	Standard of Galvanizing Steel Sections	
16	Standard of Galvanizing Bolts and Nuts	
	Brittleness	
17	Standard of Checking embrittlement	
18	Estimated Weight of Tower Including Galvanization, Gusset Plates, Foundation Stubs, Nuts and Bolts	

	Tower type EG			
	2m Leg extension(Single) for Tower type EG			
	4m Leg extension(Single) for Tower type EG			
	6m Leg extension(Single) for Tower type EG			
	8m Leg extension(Single) for Tower type EG			
19	The offered material is corrosion resistant to the atmospheric heavy pollution and at coastal areas			

Notes: 1) Bidder has to fill-up above details to verify the Technical Data of his proposed Manufacturer
2) All values shall be in metric system.

Signed and Stamp by the Manufacturer

Signed and Stamped by the Bidder

7. SCHEDULE OF TECHNICAL DATA FOR POLES SPA, SPD & SPG

Sr.No	Description	Pole Type		
		SPA	SPD	SPG
1	Manufacturer's Name			
2	Ultimate Tensile Strength			
3	Minimum Guaranteed Yield Strength of Steel Used			
4	**Elongation in 50mm Gauge Length Percent:**			
	a. Minimum upto 5mm Thickness			
	Elongation in 200mm Gauge Length Percent Minimum:			
	b. 5mm to 16mm Thickness			
	c. Over 16mm Thickness			
5	**Chemical Composition of Steel Used:**			
	a. Carbon			
	b. Manganese			
	c. Phosphorous			
	d. Sulphur Max			
	e. Any Other			
6	Name of process of making steel	Open-hearth, Basic Oxygen		
7	Height of Pole			
8	**Shape of Pole:**			
	a-Circular/Polygonal			
9	Type of Pole: Embedded Type/Anchor Base Type			
10	No of Section			
11	**Length of Each Section:**			
	a. Top			
	b. Middle			
	c. Bottom			
12	**Thickness of Each Section:**			
	a. Top			

	b. Middle			
	c. Bottom			
13	Diameter of Pole at Base/Top			
14	**Anchor Bolts:**			
	a. No of Bolts			
	b. Length of Bolts			
	c. Type of Material for Anchor Bolts			
	d. No and Size of Washers			
	e. Type of Material for Washers			
15	**Thickness of Base Plate:**			
	a. Depth of Embedded Part or Section			
	b. Outer Diameter /Thickness of Embedded Part or Section			
16	**Coupling Method:**			
	a. Slip Joint			
17	Length of Cross Arm			
18	**Shape of Cross Arms:**			
	a. Circular/Polygonal			
	b. Horizontal/Upward Swooping			
19	**Removable Ladder:**			
	a- Material			
	b- Shape			
20	Step of removable ladder			
21	**Welding:**			
	Method of Welding			
22	**Galvanizing:**			
	Standard of Galvanizing for Pole and Cross Arm			
23	Standard of Galvanizing for Nuts and Bolts etc			
24	**Weight:** Weight of Sections:			
	a- Top			

	b- Middle			
	c- Bottom			
25	Weight of Cross Arm			
26	Weight of Anchor Bolts, Nuts and Washers			
27	Weight of Embedded Part/Other Parts			
28	Total Weight of Pole and Cross Arm			

Notes: 1) Bidder has to fill-up above details to verify the Technical Data of his proposed Manufacturer
2) All values shall be in metric system.

Signed and Stamp by
the Manufacturer

Signed and Stamped by
the Bidder

8. SCHEDULE OF TECHNICAL DATA FOR POLES SP-AC,SP-DC & SP-GC

Sr.No	Description	Pole Type		
		SP-AC	SP-DC	SP-GC
1	Manufacturer's Name			
2	Ultimate Tensile Strength			
3	Minimum Guaranteed Yield Strength of Steel Used			
4	**Elongation in 50mm Gauge Length Percent:**			
	a. Minimum upto 5mm Thickness			
	Elongation in 200mm Gauge Length Percent Minimum:			
	b. 5mm to 16mm Thickness			
	c. Over 16mm Thickness			
5	**Chemical Composition of Steel Used:**			
	a- Carbon			
	b- Manganese			
	c- Phosphorous			
	d- Sulphur Max			
	e- Any Other			
6	Name of process of making steel	Open-hearth, Basic Oxygen		
7	Height of Pole			
8	**Shape of Pole:**			
	a-Circular/Polygonal			
9	Type of Pole: Embedded Type/Anchor Base Type			
10	No of Section			
11	**Length of Each Section:**			
	a- Top			
	b- Middle			
	c- Bottom			
12	**Thickness of Each Section:**			
	a- Top			

	b- Middle			
	c- Bottom			
13	Diameter of Pole at Base/Top			
14	**Anchor Bolts:**			
	a- No of Bolts			
	b- Length of Bolts			
	c- Type of Material for Anchor Bolts			
	d- No and Size of Washers			
	e- Type of Material for Washers			
15	**Thickness of Base Plate:**			
	a- Depth of Embedded Part or Section			
	b- Outer Diameter /Thickness of Embedded Part or Section			
16	**Coupling Method:**			
	a- Slip Joint			
17	Length of Cross Arm			
18	**Shape of Cross Arms:**			
	a- Circular/Polygonal			
	b- Horizontal/Upward Swooping			
19	**Removable Ladder:**			
	a- Material			
	b- Shape			
20	Step of removable ladder			
21	**Welding:**			
	Method of Welding			
22	**Galvanizing:**			
	Standard of Galvanizing for Pole and Cross Arm			
23	Standard of Galvanizing for Nuts and Bolts etc			
24	**Weight:** Weight of Sections:			
	a- Top			

	b- Middle			
	c- Bottom			
25	Weight of Cross Arm			
26	Weight of Anchor Bolts, Nuts and Washers			
27	Weight of Embedded Part/Other Parts			
28	Total Weight of Pole and Cross Arm			

Notes: 1) Bidder has to fill-up above details to verify the Technical Data of his proposed Manufacturer
2) All values shall be in metric system.

Signed and Stamp by
the Manufacturer

Signed and Stamped by
the Bidder

9. SCHEDULE OF TECHNICAL DATA FOR POLES SPT-C,SPM-C & SPH-C

Sr.No	Description	Pole Type		
		SPT-C	SPM-C	SPH-C
1	Manufacturer's Name			
1a	Standard followed for steel poles and cross arms			
2	Ultimate Tensile Strength			
3	Minimum Guaranteed Yield Strength of Steel Used			
4	**Elongation in 50mm Gauge Length Percent:**			
	a. Minimum upto 5mm Thickness			
	Elongation in 200mm Gauge Length Percent Minimum:			
	b. 5mm to 16mm Thickness			
	c. Over 16mm Thickness			
5	**Chemical Composition of Steel Used:**			
	a- Carbon			
	b- Manganese			
	c- Phosphorous			
	d- Sulphur Max			
	e- Any Other			
6	Name of process of making steel	Open-hearth, Basic Oxygen		
7	Height of Pole			
8	**Shape of Pole:**			
	a-Circular/Polygonal			
9	Type of Pole: Embedded Type/Anchor Base Type			
10	No of Section			
11	**Length of Each Section:**			
	a- Top			
	b- Middle			
	c- Bottom			

12	**Thickness of Each Section:**			
	a- Top			
	b- Middle			
	c- Bottom			
13	Diameter of Pole at Base/Top			
14	**Anchor Bolts:**			
	a- No of Bolts			
	b- Length of Bolts			
	c- Type of Material for Anchor Bolts			
	d- No and Size of Washers			
	e- Type of Material for Washers			
15	**Thickness of Base Plate:**			
	a- Depth of Embedded Part or Section			
	b- Outer Diameter /Thickness of Embedded Part or Section			
16	**Coupling Method:**			
	a- Slip Joint			
17	Length of Cross Arm			
17a	Diameter of cross Arm: a) At pole shaft b) At tip of cross arm			
17b	Thickness of cross arm			
18	**Shape of Cross Arms:**			
	a- Circular/Polygonal			
	b- Horizontal/Upward Swooping			
19	**Removable Ladder:**			
	a- Material			
	b- Shape			
20	Step of removable ladder			
21	**Welding:**			
	Method of Welding			
22	**Galvanizing:**			
	Standard of Galvanizing for Pole and Cross Arm			
22a	Thickness of Galvanizing			

22b	**Painting of Steel Poles(TP):** a) No of coats inside of pole b) No of coats outside of pole c) Thickness of coating inside of pole(μm) d) Thickness of coating outside of pole(μm)			
23	Standard of Galvanizing for Nuts and Bolts etc			
24	**Weight:** Weight of Sections:			
	a- Top			
	b- Middle			
	c- Bottom			
	d- Base Plate			
25	Weight of Cross Arm			
26	Weight of Anchor Bolts, Nuts and Washers			
27	Weight of Connection Flanges, Brackets, Bolts, Nuts and Washers			
28	Weight of Templates:			
	a. Upper			
	b. Bottom			
29	Weight of Anti Climbing device			
30	Weight of name, danger & phase plates etc.			
31	Weight of metal cover for anchor bolts			
32	Weight of Embedded Part/Other Parts			
33	Total Weight of Pole and Cross Arm etc			

Notes: 1) Bidder has to fill-up above details to verify the Technical Data of his proposed Manufacturer
2) All values shall be in metric system.

Signed and Stamp by the Manufacturer

Signed and Stamped by the Bidder

10. SCHEDULE OF TECHNICAL DATA FOR AASC CONDUCTOR GREELEY

A-

1.	i) Manufacturer's Name & Address	______________
	ii) Standard Followed	______________
2.	Correspondence Address	______________
3.	Telex reference of Manufacturer	______________
4.	Fax No. of Manufacturer	______________

B- <u>DATA OF COMPLETE CONDUCTOR</u>

5.	Code Name	______________
6.	Diameter (mm)	______________
7.	Cross section (mm^2)	______________
8.	D.C. Resistance at 20ºC (Ω/km)	______________
9.	Rated ultimate strength (Kg)	______________
10.	Weight (Kg/km)	______________
11.	Lay Ratio:	
	i) Outer most layer	______________
	ii) Layer immediately beneath outside Layer	______________
	iii) Inner most layer for conductor with more than one layer	______________
12.	Direction of lay (outer most layer)	______________
13.	Strong strain curves (quote reference No. for each curve mentioned below).	______________
	i) Initial stress strain curve without creep	______________
	ii) Initial stress strain curve with one hour creep	______________
	iii) Final stress strain curve	______________

C- <u>DATA FOR ALUMINIUM ALLOY</u>

14. No. of wires ______________________

15. Diameter of each wire (mm) ______________________

16. Diameter of outer most layer (mm) ______________________

    a) Diameter of layer immediately beneath outer most layer (mm) ______________________

    b) Diameter of inner most layer (mm) ______________________

17. Total Cross Section (mm^2) ______________________

18. Resistivity at 20ºC (Ω-mm^2/km) ______________________

19. <u>Material</u>

    a) Composition ______________________

    b) Impurities ______________________

    c) Treatment ______________________

20. <u>Minimum ultimate tensile stress</u>

    a) Before Stranding (Kg/mm^2) ______________________

    b) After Stranding (Kg/mm^2) ______________________

21. Density at 20ºC (Kg/dm^3) ______________________

22. Co-efficient of linear expansion /ºC ______________________

23. Constant mass temperature Co-efficient /ºC ______________________

24. Type of joints in base rod ______________________

25. Type of joints in individual wires (During Stranding) ______________________

26. Distance between two consecutive Joints in complete stranded conductor (m) ______________________

27. Distance over which resistance butt welding joints shall be annealed (mm). ______________________

28. Elongation of single wire

    a) Before Stranding (%) ______________________

    b) After Stranding) (%) ______________________

29. Type of joints in base rod. ______________________

30. Grease (applicable only if ordered to do so).

a) Composition ______________________

b) Guaranteed Dropping Temperature ______________________

D- <u>REEL</u>

31	i)	Outside width	(mm)	______________________
	ii)	Flange Diameter	(mm)	______________________
	iii)	Drum Diameter	(mm)	______________________
	iv)	Flange Thickness	(mm)	______________________
	v)	Inside Width	(mm)	______________________
	vi)	Lagging Thickness	(mm)	______________________
	vii)	Arbor Hole Diameter	(mm)	______________________

32. Progressive used for wooden reels

33. Length of conductor on reel (m) ______________________

34. Weight of reel with conductor (Kg) ______________________

35. Weight of reel without conductor (Kg) ______________________

36. Detailed Reel drawings are to be submitted ______________________

37. All tests, as called for in the Technical Provisions, will be carried out within the quoted cost YES ______________________

Note: 1) Bidder has to fill-up above details to verify the Technical Data of his proposed manufacturer.
2) All values shall be in metric system.

______________________ ______________________

Signed and Stamp by the Manufacturer

Signed and Stamped by the Bidder

11. SCHEDULE OF TECHNICAL DATA FOR DISC INSULATORS FOG TYPE (80kN, 100kN &120kN)

80KN 100kN 120kN

1. i) Manufacturer's Name and Address ______________________

   ii) Standard Followed P-8 and relevant specified standards

2. Porcelain Disc Diameter (mm) ______________________

3. Disc Unit Spacing (mm) ______________________

4. Minimum Creepage Distance (mm) ______________________

5. Combined Mechanical & Elect Strength (KN) ______________________

6. Mech. Impact Strength (m-KN) ______________________

7.

Average Flash over voltage	Low Frequency	Dry/kV	
		Wet/kV	
	Critical Impulse	Positive/kV	
		Negative/kV	

8. Power Frequency Puncture Voltage ______________________

9.

Radio influence voltage	Test voltage to ground/kV	
	Max. Riv. At 1000 kHZ/ kV	

10. Net weight Kg ______________________

11. Colour of Glaze ______________________

12. Standard & Material of Locking Device ______________________

13. Dimensions of Standard Ball & Socket Couplings ______________________

14. Tolerance on the Diameter ______________________

15. Positive Tolerance on the min creepage distance ______________________

16. Corona extinction voltage (rms) under dry condition, for single unit ______________________

17. Steepness of the impulse voltage which the disc unit can withstand in Steep Wave Front Test ________________________kV/µsec

18. Type test reports of following tests submitted with the bid for offered insulators (Yes/No)

-Thermal Mechanical Performance Test ________________________________

- Power Arc Test ________________________________

- Steep Wave Test ________________________________

- Artificial Pollution Performance Test ________________________________

19. No. of fog type units with zinc sleeve supplied in past 10 years:
- Domestic ________________________________
- Abroad ________________________________

20. Manufacturer's catalogue No. of offered Insulators ______________________________

21. All tests, as called for in the Technical Specifications, will be carried out within the quoted cost

22. Packing Specifications As Per relevant clauses

Signed and Stamp by the Manufacturer

Signed and Stamped by the Bidder

12. SCHEDULE OF TECHNICAL DATA FOR SINGLE SUSPENSION STRING FOR GREELEY

Sr. No	Description		SS-G (Galvanized)
1.	i)	Manufacturer's Name & Address	
	ii)	Standard Followed	
2.	**Self-Locking Ball Hook**		
	i)	Standard	
	ii)	Ball size	
	iii)	Hook Width 'A'	
	iv)	Hook Height 'B'	
	v)	Hook Opening 'C'	
	vi)	Radius 'D'	
	vii)	Dimension 'E'	
	viii)	Failing Load (Kg)	
	ix)	Material & Process of Manufactures	
	x)	Weight	
3.	**Socket Eye**		
	i)	Socket Size 'A'	
	ii)	Eye Size 'E'	
	iii)	Eye Thickness 'C'	
	iv)	Eye Width 'B'	
	v)	Height 'D'	
	vi)	Hole Diameter 'F'	
	vii)	Material & Process of Manufacture	
	viii)	Material of Split Pin	
	ix)	Failing Load (Kg)	
	x)	Weight (Kg)	
4.	**Arcing Horn**		
	i)	Length 'A'	
	ii)	Height 'B'	
	iii)	Diameter 'C'	
	iv)	Dimension 'D'	
	v)	Bolt Diameter 'E'	
	vi)	Material & Process of Manufacture	
	vii)	Material of Spring Washer	
	viii)	Material of Bolts & Nuts	
	ix)	Failing Load (Kg)	
	x)	Weight (Kg)	
5.	**Suspension Clamp**		
	i)	Saddle Diameter 'F'	
	ii)	Length of Clamp 'A'	
	iii)	Clamp Width 'B'	

	iv)	Height ‘C’	
	v)	Opening ‘D’	
	vi)	Rivet Pin Diameter ‘E’	
	vii)	Diameter of U-Bolt/No. of Bolts	
	viii)	Material & Process of Manufacture of Body & Keeper	
	ix)	Material for Connecting Pieces Bolts, Nuts, Lock Washers	
	x)	Material of Cotter Pins	
	xi)	Resistance of Conductor Slippage	
	xii)	Failing Load (vertically applied load)	
	xiii)	Weight	
6.	The offered material is corrosion resistant to the atmospheric heavy pollution and at coastal areas		(Yes/No)

Notes: 1) Bidder has to fill-up above details to verify the Technical Data of his proposed Manufacturer

2) All values shall be in metric system.

Signed and Stamp by the Manufacturer

Signed and Stamped by the Bidder

13. SCHEDULE OF TECHNICAL DATA FOR SINGLE JUMPER STRINGS FOR GREELEY

			JS-G (Galvanized)
1.	i)	Manufacturer’s Name & Address	___________
	ii)	Standard Followed	___________
	iii)	Website of Manufacturer	___________
	iv)	Contact Person of Manufacturer for this Project	___________
	v)	Email of Contact Person	___________
	vi)	Address of Manufacturing Facility	___________
2.		**SELF LOCKING BALL HOOK**	
	i)	Standard	___________
	ii)	Ball Size	___________
	iii)	Hook Width ‘A’	___________
	iv)	Hook Height ‘B’	___________
	v)	Hook Opening ‘C’	___________
	vi)	Radius ‘D’	___________
	vii)	Dimension ‘E’	___________
	viii)	Failing Load (Kg)	___________
	ix)	Material & process of manufactures	___________
	x)	Weight	___________
3.		**SOCKET EYE**	
	i)	Socket Size ‘A’	___________
	ii)	Eye Size ‘E’	___________
	iii)	Eye Thickness ‘C’	___________
	iv)	Eye Width ‘B’	___________
	v)	Height ‘D’	___________
	vi)	Hole Diameter ‘F’	___________
	vii)	Material & process of manufacture of Socket Eye	___________
	viii)	Material of Split Pin	___________

	ix)	Failing Load (Kg)	____________
4.		**ARCING HORN**	
	i)	Length ‘A’	____________
	ii)	Height ‘B’	____________
	iii)	Diameter ‘C’	____________
	iv)	Dimension ‘D’	____________
	v)	Bolt Diameter ‘E’	____________
	vi)	Material & process of manufacture of arcing horn	____________
	vii)	Material of spring washer	____________
	viii)	Material of Bolts & Nuts	____________
	ix)	Failing Load (Kg)	____________
	x)	Weight (Kg)	____________
5.		**SUSPENSION CLAMP**	
	i)	Saddle Diameter ‘F’	____________
	ii)	Length of Clamp ‘A’	____________
	iii)	Clamp Width ‘B’	____________
	iv)	Height ‘C’	____________
	v)	Opening ‘D’	____________
	vi)	Rivet Pin Diameter ‘E’	____________
	vii)	Diameter of U-Bolt/No. of Bolts	____________
	viii)	Material & process of manufacture of Body & Keeper	____________
	ix)	Material for Connecting Pieces Bolts, Nuts & Lock Washers	____________
	x)	Material of Cotter Pin	____________
	xi)	Resistance of Conductor Slippage	____________
	xii)	Failing Load (vertically applied load)	____________
6		The offered material is corrosion resistant to the atmospheric heavy pollution and at coastal areas	(YES/NO)
7.		All tests, as called for in the Technical Provisions, will be carried out within the quoted cost	YES

Notes: 1) Bidder has to fill-up above details to verify the Technical Data of his proposed Manufacturer

2) All values shall be in metric system.

Signed and Stamp by
the Manufacturer

Signed and Stamped by
the Bidder

14. SCHEDULE OF TECHNICAL DATA FOR SINGLE TENSION STRINGS FOR GREELEY

Sr.No	Description		ST-G (Galvanized)
1.	i)	Manufacturer's Name & Address	
	ii)	Standard Followed	
2.	**Self-Locking Ball Hook**		
	i)	Standard	
	ii)	Ball Size	
	iii)	Hook Width 'A'	
	iv)	Hook Height 'B'	
	v)	Hook Opening 'C'	
	vi)	Radius 'D'	
	vii)	Dimension 'E'	
	viii)	Failing Load	
	ix)	Material & Process of Manufacture	
	x)	Weight	
3.	**Socket Eye**		
	i)	Socket Size	
	ii)	Eye Size 'E'	
	iii)	Eye Thickness	
	iv)	Eye Width 'B'	
	v)	Height 'D'	
	vi)	Hole Diameter 'E'	
	vii)	Material & Process of Manufacture	
	viii)	Material of Socket Split Pin	
	ix)	Failing Load	
	x)	Weight	
4.	**Arcing Horn**		
	i)	Length 'A'	
	ii)	Height 'B'	
	iii)	Diameter 'C'	
	iv)	Dimension 'D'	
	v)	Bolt Diameter 'E'	
	vi)	Material & Process of Manufacture	
	vii)	Material of Spring Washer	
	viii)	Material of Bolts, Nuts	
	ix)	Failing Load (kg)	
	x)	Weight (kg)	
5.	**Shackle (L.S)**		
	i)	Opening 'A'	
	ii)	Pin Diameter 'B'	
	iii)	Height 'C'	

	iv)	Radius 'D'	
	v)	Thickness 'E'	
	vi)	Material & Process of Manufacture	
	vii)	Material of Rivet Pin	
	viii)	Material of Washer	
	ix)	Material of Split Pin	
	x)	Failing Load	
	xi)	Weight	
6.	**a**	**Tension Clamp (Compression Type)**	
	i)	Failing Load	
	ii)	Weight	
	iii)	Result of Heat Cycle Test provided with the bid (Yes/No)	
	b	**Aluminium Compression Dead End**	
	i)	Inner Diameter	
	ii)	Outer Diameter	
	iii)	Length (l)	
	iv)	Die Size	
	v)	Material & Process of Manufacture	
	c	**Jumper Terminal**	
	i)	No. of Bolts	
	ii)	Length of Jumper Terminal	
		- Before Compression	
		- After Compression	
	iii)	Material of Bolts & Nuts	
	iv)	Material of Spring Washers	
	v)	Material of Plain Washers	
7.	The offered material is corrosion resistant to the atmospheric heavy pollution and at coastal areas		(Yes/No)

Notes: 1) Bidder has to fill-up above details to verify the Technical Data of his proposed manufacturer.
2) All values shall be in metric system.

Signed and Stamp by the Manufacturer

Signed and Stamped by the Bidder

15. SCHEDULE OF TECHNICAL DATA FOR MID SPAN JOINT (COMPRESSION SPLICE)

Sr.No	**Information Required**		**Data to be supplied by the Bidder/Manufacturer For AASC Greeley Designated as MS-G**
1.	i)	Manufacturer's Name & Address	
	ii)	Standard Followed	
2.	**Aluminium Alloy Sleeve**		
	i)	Inner Diameter	
	ii)	Outer Diameter	
	iii)	Length:	
		a) Before Compression	
		b) After Compression	
	iv)	Material & Process of Manufacture	
	v)	Weight	
3.	Dimensions after compression:		
	a)	Corner to Corner	mm
	b)	Surface to Surface	mm
4.	Die Size Aluminium		
5.	Compressor Dies, K		
6.	Failing Load		
7.	Whether factory prefilled with appropriate filler compound		YES
8.	Packing Specifications		As Per Relevant Clause
9.	Compression Pressure		Tonne
10.	Minimum corona extinction voltage under dry conditions		kV
11.	Radio Interference Voltage Under Conditions		µV
12.	All tests, as called for in the Technical Provisions, will be carried out within the quoted cost		YES
13.	Whether drawing of conductor mid span Joint submitted		YES

Note: -

i. All values shall be in metric system.
ii. Detailed dimensional drawings showing type of material and other details /data etc. must be submitted with the bid.
iii. Bidder/Manufacturer shall completely fill the Schedule of Technical Data.

Signed and Stamp by the Manufacturer	Signed and Stamped by the Bidder

16. SCHEDULE OF TECHNICAL DATA FOR REPAIR SLEEVE (RS-G)

Sr.No	Description		RS-G
1.	Manufacturer's Name & Address		
2.	Standard Followed		
3.	**Before Compression Diameter of Sleeve:**		
	i)	Inner Diameter	
	ii)	Outer Diameter	
4.	**Dimension after Compression:**		
	i)	Corner to Corner	
	ii)	Surface to Surface	
5.	**Length of Sleeve:**		
	i)	Before Compression	
	ii)	After Compression	
6.	Material & Process of Manufacture		
7.	Failing Load		
8.	Die Size		
9.	Weight of Sleeve		
10.	Packing Specifications		
11.	Compression Pressure		Tonne
12.	Minimum Corona Extinction Voltage Under Dry Conditions		kV
13.	Radio Interference Voltage Under Conditions		µV

Note: -
i. All values shall be in metric system.
ii. Detailed dimensional drawings showing type of material and other details /data etc. must be submitted with the bid.
iii. Bidder/Manufacturer shall completely fill the Schedule of Technical Data.

Signed and Stamp by the Manufacturer

Signed and Stamped by the Bidder

17. SCHEDULE OF TECHNCIAL DATA FOR STOCK BRIDGE VIBRATION DAMPERS FOR GREELEY

Sr.No	Description			SB-G (Galvanized)
1.	Manufacturer’s Name & Address			
2.	Standard Followed			
3.	Damper capability to suppress aeolian			
4.	**Supply of certified copies of following curves (Yes/No)**			
	i)	Frequency of vibration versus bending amplitude.		
	ii)	Power dissipated by damper versus vibration frequency.		
	iii)	Mechanical impedance versus vibration frequency		
	iv)	Phase angle versus vibration frequency		
	v)	Information as required under Clause-9 of specification.		
5.	**Position of fixing dampers on the conductor/ wire from the clamp mouth:**			
	i)	At Suspension Points:		
		a	With E.D.S as 12% of UTS	
		b	With E.D.S as 14% of UTS	
		c	With E.D.S as 18% of UTS	
		d	With E.D.S as 22% of UTS	
	ii)	At Tension Points:		
		a	With E.D.S as 12% of UTS	
		b	With E.D.S as 14% of UTS	
		c	With E.D.S as 18% of UTS	
		d	With E.D.S as 22% of UTS	
6.	**The number of dampers required per span for various span lengths:**			
	i)	Span lengths: 150m, 200m, 250m, 300m, 350m, 400m, 450m----600m		
	ii)	Number of dampers:		
		a.	Suspension Span	
		b.	Tension Span	
7.	Clamping Torque (kgm)			
8.	Weight of Damper			
9.	Material & Process of Manufacture of Damper Weights			
10.	Material of Clamp, Bolts & Lock Washers			

11.	Material & No. of Strands of Messenger Wire	
12.	Design of Stock Bridge Damper	4-R
13.	No. of stock bridge vibration dampers supplied in past 10 years:	
	- Domestic	
	- Abroad	
14.	The offered material is corrosion resistant to the atmospheric heavy pollution and coastal areas (**Yes/No)**	
15.	All tests as called in the technical specification will be carried out within the quoted cost	Yes
16.	Performance certificate to be provided	

Notes: 1) Bidder has to fill-up above details to verify the Technical Data of his proposed manufacturer.
2) All values shall be in metric system.

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Signed and Stamped by the Bidder

18. SCHEDULE OF TECHNCIAL DATA FOR GROUNDING MATERIAL

Sr No		Information Required	Data to be supplied by the Manufacturer
1	i	Manufacturer's Name and Address	
	ii	Standard Followed	
2	Earth Rod		
	i	Length of Rod	
	ii	Diameter	
	iii	Material	
	iv	Method used to cover steel by copper	
	v	Thickness of copper	
	vi	Weight	
3	Bronze Clamp with Non-Ferrous Safety Set Screw (Cable to Rod Connector)		
	i	Clamp size	
	ii	Screw size	
	iii	Weight	
4	Copper Wire		
	i	Length	
	ii	Diameter	
	iii	Whether solid wire as per requirement of the bidding document	
	iv	Material	
5	Compressed Terminal (Flat to Cable connector)		
	i	Terminal size	
	ii	Outer Diameter/Inner Diameter	
	iii	Material	
	iv	Size of hole	
6	Packing Specifications		

Note: -

1. All values shall be in metric system.
2. Manufacturer shall completely fill the Schedule of Technical Data.
3. Detailed dimensional drawings showing type of material etc. must be submitted with the bid.
4. Specify the name of manufacturers, in case the sub-items are made by different manufacturers.

Signed and Stamp by
the Manufacturer

Signed and Stamped by
the Bidder

19. SCHEDULE OF TECHNICAL DATA FOR ALUMOWELD SHIELD WIRE (AWS)

Sr. No	Description	
1	Origin of Material (Maker's Name and Address)	
2	Origin of Shield Wire(Maker's Name and Address)	
3	Type and Material	
4	Standard Specification Applied	
5	No of Strands	7
6	Conductivity	
7	Strand Diameter(mm)	3.26
8	Overall Diameter of Shield Wire(mm)	9.78
9	Thickness of Aluminium over Steel Strand (%)	
10	Nominal Cross Section(mm^2)	58.56
11	Ultimate Strength of Shield Wire(kg)	7226
12	Weight of Shield Wire(kg/km)	389.6
13	Nominal DC Resistance at 20^0C(Ω/km)	1.463
14	Current Carrying Capacity(Amp)	
15	Whether Shield Wire is suitable to withstand corrosion and coastal areas	Yes
16	All Tests, as called for in Technical Specification will be carried out within the quoted cost	Yes
17	Packing:	
	a) Length of Shield Wire on each drum(km)	2.0
	b) Net Weight(kg)	
	c) Gross Weight(kg)	
	d) Detail of Protective Covering	Moisture Resistant Protective Covering
18	Length of Alumoweld Shield Wire in kilometres supplied in last 10 years:	
	- Domestic	
	- Abroad	

Note: 1) Bidder has to fill-up above details to verify the Technical Data of his proposed Manufacturer
2) All values shall be in metric system.

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Signed and Stamped by the Bidder

20. SCHEDULE OF TECHNICAL DATA FOR SUSPENSION FITTINGS FOR ALUMOWELD SHIELD WIRE (Drawing #PDW/DF-320)

			SF-AWS
1.		**SUSPENSION CLAMP**	
	i)	Saddle Diameter ‘E’	___________
	ii)	Length of Clamp ‘A’	___________
	iii)	Thickness of Clamp ‘B’(To be connected with tower peak)	___________
	iv)	Height of Clamp	___________
	v)	Rivet Pin Diameter ‘D’	___________
	vi)	Material & Process of Manufacture of Body & Keeper	___________
	vii)	Material for Connecting Pieces Bolts, Nuts, Lock Washers	___________
	viii)	Material of Cotter Pins	___________
	ix)	Resistance of Conductor Slippage	___________
	x)	Failing Load (vertically applied load)	___________
	xi)	Weight	___________
2		The offered material is corrosion resistant to the atmospheric heavy pollution and at coastal areas	(YES/NO)
3		All tests, as called for in the Technical Provisions, will be carried out within the quoted cost	YES

Notes: 1) Bidder has to fill-up above details to verify the Technical Data of his proposed Manufacturer
2) All values shall be in metric system.

_________________________ _________________________

Signed and Stamp by the Manufacturer

Signed and Stamped by the Bidder

21. SCHEDULE OF TECHNICAL DATA FOR TENSION FITTINGS FOR ALUMOWELD SHIELD WIRE (Drawing # PDW/DF-319)

		TF-AWS
1.	**SHACKLE (Drawing # PDW/DF-321)**	
i)	Internal Width of Clamp ‘E’	___________
ii)	Length of Clamp ‘A’	___________
iii)	Thickness of Clamp	___________
iv)	Height ‘C’	___________
v)	Opening	___________
vi)	Pin Diameter ‘B’	___________
vii)	Radius ‘D’	___________
viii)	Material & Process of Manufacture	___________
ix)	Material of Rivet Pin	___________
x)	Material of Split Pin	___________
xi)	Failing Load	___________
xii)	Weight	___________
2.	**EYE LINK**	
i)	Thickness	___________
ii)	Length	___________
iii)	Diameter	___________
iv)	Internal Width(To be Compatible with Shackle & Tension Clamp)	___________
v)	Failing Load	___________
vi)	Material & Process of Manufacture	___________
3.	**EARTH WIRE TENSION CLAMP (Drawing PDW/DF-328)**	
i)	Dimension ‘A’	___________
ii)	Dimension ‘B’	___________
iii)	Internal Width of Clamp ’C’	___________
iv)	Dimension ‘D’	___________
v)	Dimension ‘E’	___________
vi)	Dimension ‘F’	___________

vii)	Saddle Diameter	____________
viii)	Material & process of manufacture of each component of Earth Wire Tension Clamp	____________
ix)	Failing Load	____________
x)	Weight	____________

4. **EARTHING CLAMP (Drawing # PDW/DF-321)**

i)	Opening	____________
ii)	Width	____________
iii)	Height	____________
iv)	Saddle Diameter(9.78mm)	____________
v)	Diameter of U-Bolt/No. of Bolts	____________
vi)	Failing Load	____________
vii)	Weight	____________
viii)	Material & process of manufacture of each component of Earthing Clamp	____________

5.	The offered material is corrosion resistant to the atmospheric heavy pollution and coastal areas	YES/NO
6.	All tests, as called for, will be carried out in the Technical Provision, within the quoted cost	YES

Notes: - 1) Bidder has to fill-up above details to verify the Technical Data of his proposed Manufacturer
2) All values shall be in metric system.

____
Signed and Stamp by
the Manufacturer

____
Signed and Stamped by
the Bidder

22. SCHEDULE OF TECHNICAL DATA FOR MID SPAN JOINT FOR ALUMOWELD SHIELD WIRE (AWS)

Sr.#	Description	
1	Manufacturer's Name & Address	
2	Material of Sleeve	Aluminium Alloy
3	Inner Diameter(mm)	
4	Outer Diameter(mm)	
5	Length before compression(mm)	
6	Length after compression(mm)	
7	Diameter after compression(mm)	
8	Percentage Elongation	
9	Slipping Strength(kg)	95% of UTS
10	Weight(kg)	
11	Whether drawing of shield wire splice submitted	Yes
12	All tests as called in the technical specification will be carried out within the quoted cost	Yes

Note: -
i. All values shall be in metric system.
ii. Detailed dimensional drawings showing type of material and other details /data etc. must be submitted with the bid.
iii. Bidder/Manufacturer shall completely fill the Schedule of Technical Data.

Signed and Stamp by the Manufacturer

Signed and Stamped by the Bidder

23. SCHEDULE OF TECHNCIAL DATA FOR STOCK BRIDGE VIBRATION DAMPER FOR ALUMOWELD SHIELD WIRE (AWS)

Sr No	Description		SB-9
1	Manufacturer's name and address		
2	Vibration Dampers equipped with breakaway type bolts or breakaway caps		Yes
3	All tests as called in the technical Specification will be carried out within the quoted cost		Yes
4	**Supply of certified copies of following curves (Yes/No)**		
	i)	Frequency of vibration versus bending amplitude.	
	ii)	Power dissipated by damper versus vibration frequency.	
	iii)	Mechanical impedance versus vibration frequency	
	iv)	Phase angle versus vibration frequency	
	v)	Information as required under Clause-9 of specification.	
5	**Position of fixing dampers on alumoweld shield wire (AWS) from the clamp mouth:**		
	At suspension points:		
	a	With E.D.S as 10% of UTS	
	b	With E.D.S as 12% of UTS	
	c	With E.D.S as 15% of UTS	
	At tension points:		
	a	With E.D.S as 10% of UTS	
	b	With E.D.S as 12% of UTS	
	c	With E.D.S as 15% of UTS	
6	Weight of Damper(kg)		
7	Material of Damper		
8	Material of Clamp		
9	Material of Plain, Belleville & Washers		
10	Design of Stock Bridge Damper		4-R
11	Dynamic strain caused by vibration at suspension point in vertical direction, Micro-strain		200 micro m/m(Peak-Peak)
12	Material of breakaway type head bolts or caps		Aluminium Alloy Stainless Steel

13	Size of break-away type bolt	
14	Design installation torque for break-away head bolts or caps (Kgm)	
15	Material & No of Strands of Messenger Wire	
16	Packing Specifications	As per relevant clause
17	No of vibration recorder to be used for vibration study	One
18	Whether Stock Bridge Vibration Damper drawing submitted	
19	Information regarding location of dampers for various span lengths submitted	
20	No of Stock Bridge Vibration Damper supplied in the last 10 years:	
	- Domestic	
	- Abroad	
21	Performance certificate to be provided	

Notes: 1) Bidder has to fill-up above details to verify the Technical Data of his proposed Manufacturer
2) All values shall be in metric system.

Signed and Stamp by
the Manufacturer

Signed and Stamped by
the Bidder

24. SCHEDULE OF TECHNCIAL DATA FOR HYDRAULIC COMPRESSOR AND DIES

i. 60 Ton Hydraulic Compressor

1	a	Maker's Name & Address	
	b	Type of Engine	Gasoline
	c	Nominal Compressor Thrust(tons)	60
	d	At what pressure the above stated thrust will be developed(kg/cm^2)	700
	e	Length of hose pipe(m)	5
	f	Pressure gauge and other necessary adaptors fitted with the compressor	Yes
	g	Dial range of pressure gauge (kg/cm^2)	0-1500
	h	Fuel capacity of the tank of Engine (Liter)	
	i	Total Weight of Compressor (kg)	
	j	Total Weight of Engine (kg)	
	k	Working Temperature Range (°C)	-10~55
	l	Remote Control Operation	Yes/No
	m	Packing Specifications	

ii. 100 Ton Hydraulic Compressor

1	a	Maker's Name & Address	
	b	Type of Engine	Gasoline
	c	Nominal Compressor Thrust(tons)	100
	d	At what pressure the above stated thrust will be developed(kg/cm^2)	700
	e	Length of hose pipe(m)	10
	f	Pressure gauge and other necessary adaptors fitted with the compressor	Yes
	g	Dial range of pressure gauge (kg/cm^2)	0-1500
	h	Fuel capacity of the tank of Engine (Liter)	
	i	Total Weight of Compressor (kg)	
	j	Total Weight of Engine (kg)	
	k	Working Temperature Range (°C)	-10~55
	l	Remote Control Operation	Yes/No
	m	Packing Specifications	

iii. **Compression Dies**

1	**Compression Dies**		
	a	Maker's Name & Address	
	b	One die size required for all conductor accessories	
	c	Die size for conductor compression splice (Mid Span Joint) for Greeley:	
		Aluminium	
	d	Die size for conductor repair sleeve for Greeley	
		Aluminium Alloy	
	e	Die size for conductor compression dead-end for Greeley	
		Aluminium Alloy	
	f	Die size for compression splice for alumoweld shield wire	
	g	Dies for conductor are compatible with type of compressors and accessories being supplied(indicate separately type of compressor and corresponding die)	Should be compatible
	h	Whether drawings of conductor and shield Wire dies submitted and adaptors are fitted with the compressor	Yes
	i	Packing specifications	

Notes: 1) Bidder has to fill-up above details to verify the Technical Data of his proposed Manufacturer
2) All values shall be in metric system.

Signed and Stamp by
the Manufacturer

Signed and Stamped by
the Bidder

25. SCHEDULE OF TECHNCIAL DATA FOR AERIAL SPHERE MARKER BALLS

Sr.#	Description	
1	Maker's Name & Address	
2	Visible Distance	
3	Diameter	
4	Colour	
5	Material	
6	Shape of Sphere	
7	Cable Clamp Material	
8	Bolts/Nuts/Washers	
9	Weight	
10	Thickness	
11	Drain Hole	
12	Voltage Range	
13	Allowable Wire Sag	
14	Conductor Diameter	

Notes: 1) Bidder has to fill-up above details to verify the Technical Data of his proposed Manufacturer
2) All values shall be in metric system.

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SECTION-03

TECHNICAL PROVISIONS

TABLE OF CONTENTS

1. GENERAL

The technical provision specifies the general technical requirement for galvanized steel towers, galvanized steel poles, AASC Greeley, alumoweld shield wire, fog type insulators, hardware and accessories, stock bridge dampers for conductor and shieldwire pertaining to the proposed transmission lines for the interconnection of Makran area with national grid network which are as under and may be adopted for the following 132kV transmission lines of the project.

vii. 132kV SDT Transmission Line from 132kV grid station Turbat to 132kV Grid Station Panjgoor.

viii. 132kV D/C Transmission Line from 300MW Power Plant Gwadar to 132kV Grid Station Turbat.

2. MATERIAL AND WORKMANSHIP

2.1. MATERIALS

2.1.1. All design, equipment and material shall be of highest grade, free from defects/imperfection and shall comply with and be tested in accordance with requirements of the specifications. Equipment or parts, which are not covered by the specifications, shall comply with rules, codes and regulations of the international Electro-technical Commission or approved National Standardizing Bodies. All necessary tests shall be performed to ensure that technical requirements are fulfilled.

2.1.2. The general intent of these specifications is to require the supply of equipment and materials equal or superior to those actually described herein. Unless otherwise stated, reference to the brand or manufacturer, if made, is only for the sake of comparison as to type, design, character or quality of the equipment and materials desired and shall not be interpreted as eliminating other equipment and materials of equal performance, quality and durability.

2.1.3. All dimensions and units given by the bidder in the bid and with its associated drawings and the drawings submitted by the contractor for approval shall be in metric system and all reference to weights, measurements and quantities shall be in metric units.

2.2. WORKMANSHIP

2.2.1. Workmanship and general finish shall be of the highest standard free from defects/Imperfection, in accordance with the requirements specified herein, and the best modern standard practice.

2.2.2. All components of the same design and designation shall be the best modern practices identical and like components shall be interchangeable. All necessary tests shall be performed to ensure that technical requirements are fulfilled.

3. SPECIFICATIONS AND DRAWINGS

3.1. The contract shall be executed in strict conformity with the technical provisions specification and/ or Drawings given or mentioned in this section and the contractor shall do no 'Work' without proper specification, instructions and/or drawings.

3.2. Specifications and/or drawings are intended to complement each other so that if anything is shown on the drawings as required but not mentioned in the specifications or vice versa, it shall be of like effect as if shown or mentioned in both. If any errors, omissions or discrepancies are found in the figures, specifications and/or drawings or, if any feature shall appear to the contractor to be indefinite or unclear, the same shall be referred to the Engineer whose written explanation and/or clarification shall be obtained before proceeding with the work.

3.3. Approval of the Engineer does not relieve the contractor of his responsibility to do the work in accordance with the contract.

3.4. The contractor shall be responsible for any discrepancies, errors or omissions in any drawings or other particulars supplied by him whether such drawing or particulars have been approved by the Engineer or not.

3.5. All drawings and documents furnished by the contractor in accordance with the contract shall become the property of QESCO (Client of Project).

4. STANDARDS OTHER THAN THOSE SPECIFIED

Where requirements for material or equivalent are specified by reference to a standard which has its origin in one country, it is not the intention to restrict the requirements solely to that standard and that country. Other standards, including standard of other countries, will be accepted provided the requirements thereof, in the opinion of the Engineer, are at least equal to the requirements of the standard specified. The manufacturer may propose to the Engineer an equivalent standard other than that specified, in which case he shall submit the proposed standard and all other information required in this respect and shall submit written proof that proposed standard is equivalent in all significant respects to the standard specified. All submission must be made in the English language.

5. HOT DIP GALVANIZATION REQUIREMENTS

(Applicable For Line #8)

Iron and steel products to be hot dip galvanized as per ASTM A123 under these specifications shall adhere to the coating thickness values as specified below:

Product and Thickness, t (mm)	Individual Sample Thickness (g/m²) minimum	Average Sample Thickness (g/m²) minimum
Steel t ≥ 6	840	900
Steel 3 < t < 6	720	800
Steel 1 < t ≤ 3	600	670

Iron and steel hardware to be hot dip galvanized as per ASTM A153 under these specifications shall adhere to the following coating thickness values

Class of Material as per ASTM A153	Individual Sample Thickness (g/m²) minimum	Average Sample Thickness (g/m²) minimum
Class A	720	800
Class B:		
B-1	720	800
B-2	710	770
B-3	710	770
Class C	420	460
Class D	285	360

compatibility with the steel by the supplier. Wherever necessary, the composition of steel shall be modified so that the above coating thickness values are obtained. All galvanized components shall be suitable for coastal and desert pollution/corrosion. The above mentioned zinc coating thickness values are for general guidance. However, it is the responsibility of the supplier/bidder to ascertain suitable zinc coating thickness values for coastal and desert corrosion/pollution.

6. PAINTING SPECIFICATION OF GALVANIZED OHL STRUCTURES

(Applicable For Line# 8 “Zone A” Only)

6.1 GENERAL REQUIREMENTS

All galvanized steel poles and lattice towers are to be painted. Inside of the poles shall be painted in the manufacturers premises.

This specification defines the minimum requirements for the protective coating of the poles. Also for surface cleaning, preparation and application of paints.

The relevant requirements of the SA and DIN standards and of the standard SIS 05 5900, shall apply. If the above mentioned documents and the specifications are in conflict, the stricter one shall govern.

The Client/Engineer shall at all times have access to the work and materials for inspecting while the works is in preparation or progress.

If any work or material be found defective or not in compliance with the specifications, correction or replacement by the contractor at his own cost is essential.

6.2 RESPONSIBILITY AND GUARANTEES

Inspection of coating by the Client/Consultant will neither relieve the manufacturer of the responsibility for the good quality of paint, nor the contractor, of his responsibility for acquiring the specified quality of materials, nor for the correct performance of the work. The steel structures are to be protected against corrosion and damage through the influence of weathering, i.e. tropical conditions, including the incidence of dust, and storms and sea water spray. The contractor shall bear the responsibility for all losses and damages that occur through inadequate corrosion protection and shall repair or replace the parts at his cost.

The contractor shall bear the full responsibility for paint applied by him on surfaces primed or painted by others.

Corrosion protection is rated to last a guaranteed 15 (FIFTEEN) years after Client's/Engineer's Final Inspection and Acceptance.

6.3 SAFETY PRECAUTIONS

All necessary precautions shall be taken by the supplier to protect personnel and property from hazards due to falls, injuries, toxic fumes, fires, explosion or other harm.

All paints and thinners shall be stored in an area that is well ventilated and protected from sparks, flame, direct rays of the sun and from excessive heat.

It shall be the responsibility of the contractor that all work to be done and all equipment used is in accordance with the local authority regulations.

Temporary constructions, ladders, scaffolding runways etc, required for safe execution of the painting work shall be rigidly built of all materials, apparatus, equipment and men thereon.

6.4 TEST INSTRUMENTS

The dry film thickness on the steel will be measured above the peaks of surface by means of an electromagnetic dry film thickness gauge, such as the "Mini test" and magnetic one such as the "Micro test".
During application of the paint, the wet film thickness is to be checked continuously by means of an approved wet film thickness gauge. Also the dew point has to be controlled continuously by means of approved instrument.
An approved type of multi-cross cutter for adhesion tests is also required and test shave is to be carried out upon the request of the Client.

6.5 CLEANING AND SURFACE PREPARATION

Before painting of hot dip galvanized towers, poles and gantries, they shall be carefully cleaned to remove all foreign matters such as salt, dichromate solutions, dust, sand and dirt by the use of sand blasting and fresh warm water containing wax-free detergent and about 0.5% ammonium hydroxide. Application will be made by using sponges.
Where additional coats of paint are being applied to surfaces having one or more coats of paint in good condition, the existing paint shall be cleaned of all foreign matters.

6.6 PAINTING - GENERAL PREPARATION AND APPLICATION

All materials in successive coats shall be of the same manufacturer unless otherwise approved and approval of manufacturers of all coating shall be obtained before relevant orders are placed.

The contractor shall obtain the paint manufacturers specific recommendations and instructions on pot life and other specific provisions for applications of both inner and outer surface coats. These recommendations shall be considered as a particular part of the specification and shall be followed accordingly. The use of thinners is strictly restricted to the cleaning of tools.

Paints shall only be applied to clean, dry surfaces after the approval of the owner and his representative.

All materials shall be evenly applied so as to be free from runs, sags, taps, skips, "holidays" or other defects only by use of approved "Strike Brushes". All finishes shall be clean and in good sound condition.

Successive coats should be of different color shades.

Dry film thickness for all coats as specified herein shall be considered as minimum unless otherwise is indicated, and regular dry film thickness checks shall be made by employing the instruments stated above.

All paint should be delivered in original sealed containers and remained unopened until required for use, paint which has livered, gelled or otherwise deteriorated during storage, shall not be used.

Surfaces completed but not meeting the standards set forth in this specification shall be re-coated at the cost of the contractor.

6.7 PAINT SPECIFICATION

All paint coating materials shall be of an approved quality obtained from reputable manufacturers. Only products with a proven reference record on galvanized transmission towers in Middle East or identical conditions in excess of 10 years are accepted.
The contractor will provide a guarantee certificate for painting system on attached schedule as Annexure (D) stating that:

1. Painting system will have a life time of rust and corrosion protection of fifteen (15) years for lower parts and twenty (20) years for the upper parts of the towers/poles.
2. Painting system will have a guaranteed life of five (5) years for all parts of the towers/poles.

Inside the tubular poles and their cross arms are to be painted by approved spraying methods in the manufacturing plant after galvanizing.

The paint to be used inside the tubes shall be as follows:

1 Coat of Polyamide Cured Epoxy Resin	M.I.O. Type
Colour Shade	Grey DB 702
Dry Film Thickness	80 microns

Outside the poles and towers and their cross arms shall be painted at site after surface cleaning and before erection. Scratches occurring during erection shall be repaired after erection. No paint is allowed to drop on insulators.

3 Coats of Polyamide Cured Epoxy Resin	M.I.O. Type
Color Shade	▪ 1st Coat Grey DB 702 ▪ 2nd Coat Dark Grey DB 703 ▪ 3rd Coat Silver-Grey DB 701
Total Dry Film Thickness	240 microns
Product Description:	
Binder	Epoxy Resin, Molecular Weight >700 Polyamine Hardener
Pigment	Micaceous Iron Oxide
Filler	Mineral Type
Solvent	Aromatic Hydrocarbons
Density	1.6
Volume Solids	56%
Solid Content	77 pbw
Dynamic Viscosity	1200-2000 mPa.s (Component A) 1500-2300 mPa.s (Component B)
Mixing Ratio	90 :10 pbw
Other Particulars:	

Pot Life	▪ 8 hours at + 23°C ▪ 5 hours at + 30°C ▪ 2 hours at + 40°C
Drying	Touch Dry After 1 Hour at + 23°C
Waiting Time Between Coats	1 Day
Application of Protective Coatings:	
-Brush Painting or -Roller Application	Max. 5% of thinner may be added if necessary
Working Conditions:	
- Temperature in (Ambient Temperature) - Humidity(Max)	+ 8°C max. + 40°C 85%

6.8 AREAS NOT TO BE PAINTED

1) Grounding point of tubular poles and lattice towers above the concrete level.
2) Insulator string attachment pins and their contact surfaces.
3) Shield wire attachment pins and their contact surfaces.

6.9 BOLTS AND NUTS

Bolts and nuts shall be cleaned by washing them in fresh warm water containing wax-free detergent and about 0.5% ammonium hydroxide.

After the erection of towers, the heads of bolts and nuts shall be painted by brush, providing a touch up coat and final coat as explained above.

7. TECHNICAL SPECIFICATIONS

7.1 All the goods and equipment, the quantities of which are defined in Price Schedules, shall be of the material in accordance with the Technical Provisions & Technical Specifications appended hereto.

7.2 Goods & material specified in the technical provisions & technical specification must comply with standards cited or other recognized standards, which ensure an equal or higher quality than the standards mentioned.

7.3 U-Bolts for suspension strings shall be supplied by the tower manufacturer to be compatible for tower type ZM1 and WPS according to drawing no. EW-TF-11 or as indicated on relevant drawings having minimum failing load of 120kN whereas V shackles for tension string shall be supplied for tower type ZM30^0, ZM30^0-(M), ZM60^0, ZM60^0 (M), WPA, WPD and EG according to drawing no. EW-TF-12 or as indicated on relevant drawings having minimum failing load of 120kN. Shackle for jumper string shall be supplied to be compatible with fixing arrangements for ZM60^0, ZM60^0(M) and WPD towers.

7.4 All U-Bolts to be supplied shall be threaded for a sufficient length to take the standard nuts plus member & washer thickness.

7.5 The conductor hardware assemblies are designed for short circuit current of 31.5kA for duration of 1 second.

7.6 For hardware fittings following scheme of insulators/fittings will be followed:

1	Conductor		AASC GREELEY (Overall Diameter.=28.14mm)
2	Shield wire		AWS(Overall Diameter =9.78 mm)
3	Insulator Type		Fog Type disc insulators with ball & socket coupling
4	Suspension Assembly		<u>Type SS-GR</u> Insulator type = 80kN X 1 Ball & Socket Size = 16mmA Design/Drawings = as per relevant specifications
5	a	Tension Assembly (For Pole Line)	<u>Type ST-GR</u> Insulator type = 100kN X 1 Ball & Socket Size = 16mmA Design/Drawings = as per relevant specifications
	b	Tension Assembly (For Tower Line)	<u>Type ST-GR</u> Insulator type = 120kN X 1 Ball & Socket Size = 16mmA Design/Drawings = as per relevant specifications
6	Corona/ RIV Values		<u>132kV system:</u> • The assembly shall be corona free at a voltage of 100kV line to ground. • The RIV test shall be performed with 50dB µV as the limiting value of radio interference characteristic.
The Corona/RIV and Power Arc Test shall be conducted on complete insulators and hardware fittings under this bidding document.			

8. TRANSMISSION LINE MATERIAL CHARACTERISTICS OF THE PROJECT

8.1 *132kV Steel Towers & Tubular Steel Poles (Applicable for Line#7)*

8.1.1. ***<u>Types of Steel Towers</u>***

i. Double Circuit Suspension Tower Type ZM1

Double circuit suspension tower type ZM1 shall be utilized for line angle upto 2^0.The tower consists of basic tower and leg extension of 3.0 and 6.0 meter. The tower shall be fabricated, supplied as per drawing no. PDW/TC-9452 and in accordance with WAPDA specification P-139/T.P, with step bolts, and anti-climbing device complete with barbed wire including fixture. Number, danger and phase plates shall be furnished and installed as per WAPDA specifications. The galvanization of towers shall be carried out in accordance with WAPDA specification P-82:81.

ii. Double Circuit Medium Angle Tower Type $ZM30^0$

Double circuit medium angle tower type $ZM30^0$ shall be utilized for line angle upto 30^0.The tower consists of basic tower and leg extension of 3.0 meter. The tower shall be fabricated, supplied as per drawing no. PDW/TC-9395 and in accordance with WAPDA specification P-139/T.P, with step bolts and anti-climbing device complete with barbed wire including fixture. Number, danger and phase plates shall be furnished and installed as per WAPDA specifications. The galvanization of towers shall be carried out in accordance with WAPDA specification P-82:81.

iii. Double Circuit Heavy Angle Tower Type ZM60^0

Double circuit heavy angle type ZM60^0 shall be utilized for line angle upto 60^0 and as well as terminal tower consists of basic tower and leg extension of 3.0 meter. The tower shall be fabricated, supplied as per drawing no.PDW/TC-9462 and in accordance with WAPDA specification P-139/T.P, with step bolts and anti-climbing device complete with barbed wire including fixture. Number, danger and phase plates shall be furnished and installed as per WAPDA specifications. The galvanization of towers shall be carried out in accordance with WAPDA specification P-82:81.

iv. Double Circuit Medium Angle Tower Type ZM30^0(M)

Double circuit medium angle tower type ZM30^0 (M) shall be utilized for line angle upto 30^0.The tower consists of basic tower and leg extension of 3.0 meter. The tower shall be fabricated, supplied as per drawing no. ST-9967 and in accordance with WAPDA specification P-139/T.P, with step bolts and anti-climbing device complete with barbed wire including fixture. Number, danger and phase plates shall be furnished and installed as per WAPDA specifications. The galvanization of towers shall be carried out in accordance with WAPDA specification P-82:81.

v. Double Circuit Heavy Angle Tower Type ZM60^0(M)

Double circuit heavy angle type ZM60^0 (M) shall be utilized for line angle upto 60^0 and as well as terminal tower consists of basic tower and leg extension of 3.0 meter. The tower shall be fabricated, supplied as per drawing no.ST-9968 and in accordance with WAPDA specification P-139/T.P, with step bolts and anti-climbing device complete with barbed wire including fixture. Number, danger and phase plates shall be furnished and installed as per WAPDA specifications. The galvanization of towers shall be carried out in accordance with WAPDA specification P-82:81.

vi. Double Circuit Angle Tower Type EG

The tower shall be fabricated and supplied as per drawing no.24209/169/TD/1E340 and in accordance with WAPDA specification P-139/T.P, with step bolts and anti-climbing device complete with barbed wire including fixture. Number, danger and phase plates shall be furnished and installed as per WAPDA specifications. The galvanization of towers shall be carried out in accordance with WAPDA specification P-82:81.

vii. Double Circuit Suspension Tower Type WPS

Double circuit suspension tower type WPS shall be utilized for line angle upto 2^0.The tower consists of basic tower and leg extension of 2.0, 4.0, 6.0 and 8.0 meters. The tower shall be fabricated and supplied as per drawing no.NTDCL-AIC-WPS-1730 and in accordance with WAPDA specification P-139/T.P, with step bolts, and anti-climbing device complete with barbed wire including fixture. Number, danger and phase plates shall be furnished and installed as per WAPDA specifications. The galvanization of towers shall be carried out in accordance with WAPDA specification P-82:81.

viii. Double Circuit Medium Angle Tower Type WPA

Double circuit medium angle tower type WPA shall be utilized for line angle upto 30^0.The tower consists of basic tower and leg extension of 2.0, 4.0, 6.0 and 8.0 meters. The tower shall be fabricated and supplied as per drawing no. NTDCL-AIC-WPA-1730 and in accordance with WAPDA specification P-139/T.P, with step bolts and anti-climbing device complete with barbed wire including fixture. Number, danger and phase plates shall be furnished and installed as per WAPDA specifications. The galvanization of towers shall be carried out in accordance with WAPDA specification P-82:81.

ix. Double Circuit Heavy Angle Tower Type WPD

Double circuit heavy angle type WPD shall be utilized for line angle upto 60^0 and as well as terminal tower consists of basic tower and leg extension of 2.0, 4.0, 6.0 and 8.0 meters. The tower shall be fabricated, and supplied as per drawing no. NTDCL-AIC-WPD-1730 and in accordance with WAPDA specification P-139/T.P, with step bolts and anti-climbing device complete with barbed wire including fixture. Number, danger and phase plates shall be furnished and installed as per WAPDA specifications. The galvanization of towers shall be carried out in accordance with WAPDA specification P-82:81.

The following standards may be used for fabrication of various towers to be supplied under the bidding document:

Sr.No.	Description	Standard of Steel for Structure	Standard of Steel for Nuts & Bolts
1.	Tower Type ZM1,ZM30^0,ZM60^0, ZM30^0(M),ZM60^0 (M),EG ·WPS,WPA & WPD		ISO 898/Grade 6.8 except where noted otherwise.
	Member marked 'H'	ST52 or equivalent	
	Other members	ST42 or equivalent	

All Nuts and Bolts to be supplied with towers shall be of grade as specified and shall be of M16 and M20 or otherwise mentioned on all relevant drawings. One full set of bolt includes one bolt, one plain washer (5mm thick), one nut and lock nut. The length of bolts given on drawings shall also be increased accordingly as given on drawings to accommodate lock nuts. The dimensions of bolts, plain washers, nuts and lock nuts shall be as per following standards.

Sr. No.	Description	Standard to be used for Dimensions
1.	Bolts	DIN7990
2.	Plain Washers	DIN126
3.	Nuts	DIN555
4.	Lock Nuts	DIN936

8.1.2. <u>Types of Steel Tubular Poles</u>

The transmission line poles shall consist of a galvanized steel pole having base plate with six cross arms. The pole and cross arms shall be of polygonal shape and tapered uniformly. The assembly of all sections shall be achieved by slip joints.

The poles types SPA, SPD and SPG shall be manufactured and supplied in accordance with drawing nos:WG-PK-632-001(Assembly drawing for SPA), WG-PK-632-001(Assembly drawing for SPD) and WG-PK-632-001(Assembly drawing for SPG) respectively with high strength anchor bolts, nuts washer etc, upper and lower templates, removable ladders/step bolts and its hinges/ brackets shall also be provided on pole shaft. The material of steel poles, cross arms, nuts & bolts etc. shall be as given on relevant drawings of steel poles. However, general specifications for steel poles and its galvanization shall be as per WAPDA specification P166:83.

The type of 132kV steel poles shall be as under:

SPA	Suspension Pole	Upto 2^0
SPD	Medium Angle Pole	Upto 30^0
SPG	Heavy Angle Pole	Upto 60^0 and Terminal Pole

8.2 *132kV Steel Towers & Tubular Steel Poles (Applicable for Line#8)*

8.2.1. Types of Steel Towers

i. Double Circuit Suspension Tower Type WPS

Double circuit suspension tower type WPS shall be utilized for line angle upto 2^0.The tower consists of basic tower and leg extension of 2.0, 4.0, 6.0 and 8.0 meters. The tower shall be fabricated and supplied as per drawing no. NTDCL-AIC-WPS-1730 and in accordance with WAPDA specification P-139/T.P, with step bolts, and anti-climbing device complete with barbed wire including fixture. Number, danger and phase plates shall be furnished and installed as per WAPDA specifications. The galvanization of towers shall be carried out in accordance with clause 5 of technical provisions and WAPDA specification P-82:81.The quantity of tower types WPS of "ZONE A" as mentioned in BOQ shall also be painted after galvanization as per clause 6 of this technical provisions.

ii. Double Circuit Medium Angle Tower Type WPA

Double circuit medium angle tower type WPA shall be utilized for line angle upto 30^0.The tower consists of basic tower and leg extension of 2.0, 4.0, 6.0 and 8.0 meters. The tower shall be fabricated and supplied as per drawing no. NTDCL-AIC-WPA-1730 and in accordance with WAPDA specification P-139/T.P, with step bolts and anti-climbing device complete with barbed wire including fixture. Number, danger and phase plates shall be furnished and installed as per WAPDA specifications. The galvanization of towers shall be carried out in accordance with clause 5 of technical provisions and WAPDA specification P-82:81. The quantity of tower types WPA of "ZONE A" as mentioned in BOQ shall also be painted after galvanization as per clause 6 of this technical provisions.

iii. Double Circuit Heavy Angle Tower Type WPD

Double circuit heavy angle type WPD shall be utilized for line angle upto 60^0.The tower consists of basic tower and leg extension of 2.0, 4.0, 6.0 and

8.0 meters. The tower shall be fabricated and supplied as per drawing no. NTDCL-AIC-WPD-1730 and in accordance with WAPDA specification P-139/T.P, with step bolts and anti-climbing device complete with barbed wire including fixture. Number, danger and phase plates shall be furnished and installed as per WAPDA specifications. The galvanization of towers shall be carried out in accordance with clause 5 of technical provisions and WAPDA specification P-82:81. The quantity of tower types WPD of “ZONE A” as mentioned in BOQ shall also be painted after galvanization as per clause 6 of this technical provisions.

iv. Double Circuit Angle Tower Type EG

The tower shall be fabricated and supplied as per drawing no. 24209/169/TD/1E340 and in accordance with WAPDA specification P-139/T.P, with step bolts and anti-climbing device complete with barbed wire including fixture. Number, danger and phase plates shall be furnished and installed as per WAPDA specifications. The galvanization of towers shall be carried out in accordance with clause 5 of technical provisions and WAPDA specification P-82:81. The quantity of tower types EG of “ZONE A” as mentioned in BOQ shall also be painted after galvanization as per clause 6 of this technical provisions.

The following standards may be used for fabrication of various towers to be supplied under the bidding document:

Sr.No.	Description	Standard of Steel for Structure	Standard of Steel for Nuts & Bolts
1.	Tower Type WPS,WPA ,WPD & EG		ISO 898/Grade 6.8 except where noted otherwise.
	Member marked ‘H’	ST52 or equivalent	
	Other members	ST42 or equivalent	

All Nuts and Bolts to be supplied with towers shall be of grade as specified and shall be of M16 and M20 or otherwise mentioned on all relevant drawings. One full set of bolt includes one bolt, one plain washer (5mm thick), one nut and lock nut. The length of bolts given on drawings shall also be increased accordingly as given on drawings to accommodate lock nuts. The dimensions of bolts, plain washers, nuts and lock nuts shall be as per following standards. The galvanization of nuts and bolts shall be carried out in accordance with clause 5 of technical provisions and WAPDA specification P-82:81.

Sr. No.	Description	Standard to be used for Dimensions
1.	Bolts	DIN7990
2.	Plain Washers	DIN126
3.	Nuts	DIN555
4.	Lock Nuts	DIN936

8.2.2. ***Steel Tubular Poles*** **(New)**

8.2.2.1 **Scope:**

This specification covers technical requirements of design, manufacture and testing of transmission line steel tubular poles and design of pole foundations.

Types of Poles

The transmission lines poles shall consist of a galvanized steel pole with six cross arms and shall be bolted on an anchor bolt system embedded in foundation. The pole and cross arms shall be polygonal in shape. The poles shall be comprised of preferably not more than three sections and assembly of all section shall be achieved by slip joints. The poles shall be supplied with high strength anchor bolts, nuts, washers, upper and lower steel templates, removable ladders & brackets, anticlimbing device, name, danger & phase plates etc. The inside and outside of poles shall be painted after galvanization in accordance with clause 6 of this technical provisions.

The steel poles with single conductor shall be of the following types:

SPT-C	Tangent Pole	Upto 2^0
SPM-C	Medium Angle Pole	Upto 30^0
SPH-C	Heavy Angle Pole	Upto 60^0 and Terminal Pole

SP stands for steel pole, T stands for Tangent, M for medium angle & H for heavy angle whereas C stands for “coastal area”.

- The pole type SPT-C shall be designed according to outline drawing no. ENM/GTP-201.Height of pole from bottom cross arm to ground in case of pole type SPT-C shown as 15.5 meter. Manufacturer is required to design 3 meter and 6 meter extension to be dimensioned in such a way that standard/normal pole segment should be compatible with extended pole to achieve height of pole from bottom cross arm to ground as 18.5 meter and 21.5 meter respectively. The total number of sections with standard pole and standard pole with extension shall preferably not be more than three.

- The pole type SPM-C shall be designed according to outline drawing no. ENM/GTP-202.Height of pole from bottom cross arm to ground in case of pole type SPM-C shown as 13 meters. Manufacturer is required to design 3m and 6m extension to be dimensioned in such a way that standard/normal pole segment should be compatible with extended pole to achieve height of pole from bottom cross arm to ground as 16 meters and 19 meters respectively. The total number of sections with standard pole and standard pole with extension shall preferably not be more than three.

- The pole type SPH-C shall be designed according to outline drawing no. ENM/GTP-203.Height of pole from bottom cross arm to ground in case of pole type SPH-C shown as 13 meter. Manufacturer is required to design 3 meter and 6 meter extension to be dimensioned in such a way that standard/normal pole segment should be compatible with extended pole to achieve height of pole from bottom cross arm to ground as 16 meters and 19 meters respectively. The total number of sections with standard pole and standard pole with extension shall preferably not be more than three.

The following data shall be considered for the design of all steel poles with single conductor configurations:

Ruling Span	180m
Wind Span	200m
Weight Span	250m
Number of Conductor/Phase	1
Shield Wire	Alumoweld Shield Wire

- The initial everyday tension for AASC 'Greeley' conductor shall be considered as 12% of ultimate strength of conductor at 25ºC.
- Everyday tension for alumoweld shield wire may be taken as 10% of ultimate strength of alumoweld shield wire at 25ºC, however the shield wire sag shall not be more than 2/3rd of the conductor sag at 25ºC.
- Maximum conductor & alumoweld shield wire tension under maximum wind condition shall be 4150kg per conductor & 1650kg per alumoweld shield wire respectively.
- Maximum conductor & alumoweld shield wire tension under no wind condition shall be 2500 kg per conductor and 1250kg per alumoweld shield wire.

a) LOADINGS

Each type of pole shall be designed to safely withstand the loading due to wind on pole, conductors, hardware, alumoweld shieldwire and dead weight of pole & fittings etc. The load shall be determined in accordance with IEC Code 60826.
Maximum wind velocity (V_m) and reference wind velocity (V_R) shall be taken as 47m/sec & 31.49m/sec respectively by taking ground roughness coefficient as 0.67.The magnitude of wind loading on pole & wires is a pressure of 62 kg/m^2.

b) WIND LOAD ON CONDUCTORS

The wind load due to the effect of wind pressure upon wind span of conductors applied at the height of attachment point of middle conductor on double circuit poles & at the top of pole for ASW, shall be determined in accordance with IEC 60826(CAT: D).

c) WIND LOAD ON INSULATORS STRINGS

The wind load acting on insulator string is conceptually considered to originate from the load of the wind pressure upon wind span & transferred by the conductor and the wind pressure acting directly on the insulator string and conventionally applied at the attachment point to the support in the direction of wind shall be evaluated in accordance with specification IEC 60826(CAT: D).

d) WIND LOAD ON STEEL POLES

In order to determine the effect of the wind on the pole itself, the pole shall be divided into sections of suitable height, the ultimate wind load on the poles in the direction of wind applied at the center of gravity of a section shall be calculated according to IEC 60826 (CAT: D).

e) ULTIMATE LOADS

Transverse, longitudinal and vertical load on pole body & cross arms shall be uniformly applied along the pole/cross arms.

The loads on conductors and insulators strings shall be assumed to act at the conductor attachment points.
The loading trees shall be developed for all design conditions/load cases according to the design data, technical provisions/specifications.

Stringing conditions are considered mainly for the design of cross arms. The usability of steel for cross arms of angle poles shall not be more than 75% of yield strength of steel for all design conditions considered for design of poles. It shall be assumed that only two conductors shall be strung simultaneously and the angle between the anchorage and ground shall not be more than 15^0.

The poles shall be designed to withstand all combinations of vertical, transverse and longitudinal ultimate loads arising from the loading cases to be submitted by the contractor for the approval by the engineer before start of the detailed design of steel poles. The combination and direction of loads shall be such as to induce maximum stresses in elements. In all cases the pole shall be assumed loaded with full wind and weight spans and full line angles. Apart from all possible critical conditions likely to be occurred during stringing work and in the service life of the line, the following conditions/cases shall also be considered:

Case A
It shall be assumed that all conductors are installed and intact, the wind shall be assumed to blow:

a. In transverse direction.
b. 45^0 to the line direction

Case B
Three wires installed on one circuit and wind shall be assumed to blow:

a. In transverse direction
b. 45^0 to the line direction

Case C
For each pole it shall be assumed that relevant number of conductors is broken with the wind blowing in transverse direction.

Case D
For stringing conditions, two conductor shall be assumed to be strung simultaneously.

Case E
For terminal pole it shall be assumed that all conductors are installed and intact on one side of the pole and wind shall be assumed to blow:

a. In transverse direction
b. 45^0 to the line direction

I. Design Requirement

1. <u>General</u>

i. Each pole shall be of self-supporting with embedded anchor base foundations and shall be able to carry the loads and meet the loading conditions of this specification.

ii. The general configurations and dimensions of poles and clearance shall be as per attached drawings. The diameter of pole shall not exceed the maximum value shown. Section lengths shall not exceed 12 meter. The minimum thickness of material used for poles and cross arms shall not be less than 6mm.

iii. The contractor shall be fully responsible for the design of pole and for their satisfactory performance. All designs furnished by the contractor and approved by the Engineer shall be considered a part of this specification.

iv. All design and drawings submitted by the contractor shall become the property of the client. The client expressly reserves the right to use, reproduce in while or in part to distribute, and to reuse any and all such drawings in connection with the installation, maintenance, replacement of the materials to be furnished under the specifications and also to make any and all such drawings and reproductions thereof available to subsequent tenders and contractors, where necessary in connection with fabricating and furnishing materials duplicating or closely similar to the materials to be furnished hereunder. The depositing of all such drawing with the Engineer shall constitute a license to the client to use said drawings in the manner herein stated.

2. <u>Design Methods</u>

i. All calculations for determining allowable stresses on pole shall be according to ASCE Methods “Design of steel Transmission Pole Structure”.

ii. The pole shall be designed on computer by using software PLS CADD/PLS-POLE. All calculations carried out on computer shall be accompanied by a full explanation of the computer programmes and the methods used in the calculations. Critical calculations results of each section of the pole and cross arms shall also be submitted by the contractor on the format attached as Annexure A.

iii. As the poles are of cantilever type, consideration shall be given to the most unfavourable condition of simple buckling or combined buckling by bending and torsion.

iv. Connection between the various parts to be achieved by slip joints, the overlapping length shall be at least equal to 1.5 times the inside diameter of the female section.

v. In case of anchor base type poles the dimension and thickness of base plate as well as number, diameter and length of anchor bolts shall be determined by calculations and shall be selected from the range of some International Standard.

3. <u>Foundations</u>

i. The contractor is required to validate the suitability of pile foundation of steel poles and or design single pile foundation according to prevailing site conditions. Soil investigation report of the pole line section is attached as Annexure C.

ii. The foundation shall be able to withstand the ultimate forces such as axial forces, shear forces and bending moments etc for the worst possible combination of ultimate loads to be developed by the manufacturer.

iii. For design purposes the weight of concrete may be taken as 2300kg/m^3 and of earth as 1600kg/m^3.

iv. The foundation reaction loads at concrete level shall also be submitted by the contractor on format attached as Annexure B.

II. Material

1. Poles shall be made of low alloy high tensile steel sheet or plate having the tensile properties as specified. The steel shall be made by open hearth, basic oxygen or electric furnace process.

1.1. The manufacturer may propose steel conforming to latest applicable Industry Standards Specification and recommendation practices provided such steel has the minimum yield point and minimum elongation as specified. The manufacturer shall indicate the grade of steel and identify the standard to which the steel complies. The specification of steel shall be approved by Client/Engineer.

The following information shall be supplied by the Manufacturer:

- Ultimate Tensile Strength
- Minimum Guaranteed Yield Strength
- Minimum Elongation
- Detail of Test Piece
- Chemical Composition

2. Tensile Properties

The steels shall conform to ASTM 572 Gr 65 or equivalent the requirements as to tensile properties prescribed below:

1	Yield Point: (Minimum)	450 MPa
2	Elongation in 50mm gauge length percent, minimum	17%
3	Elongation in 200mm gauge length percent, minimum.	15%

3. Bend Test Requirement

i. The steel shall withstand the following Bend Test Requirements.

Thickness of Material	Ratio of bend diameter to thickness for specimen
For all thickness	2

4. Tolerances

i. The tolerance of steel grade and specification quoted by the contractor shall be applicable.

ii. Tolerances in the manufacturer of the poles shall be as follows:

- Overall length of pole ±10%
- Outside diameter ±1%
- Tube Thickness ±8%
- Twisting 1.5 Degree per 3m
- Weight ±3%

iii. The poles shall be straight within 1/300 of length.

III. Fabrication

1. General

i. All type of poles shall be made of one or several sections or elements tapered uniformly starting with the base or butt end, decreasing in diameter at a suitable rate. In the case of poles made of several sections their assembly shall be achieved by slip joint or flanges.

ii. Poles and crossarms shall have no transverse joints or welds and only one longitudinal weld per thickness of pole shall be permissible.

iii. The upper part of the pole shall be made to accommodate cross-arm of the dimensions and clearances shown on the drawing, necessary for the attachment of conductor and shall be made to match aesthetics of the pole. Crossarms connection to the pole shall be made by flanges.

iv. In case of anchor base type poles the lower part shall be equipped with a base plate to be anchored on a concrete foundation by means of anchor bolts.

v. The anchor base shall be of sufficient cross section to develop the full strength of the pole by means of two transverse, electric welds. The base shall telescope the pole and one weld shall be on the inside of the base at the end of the pole and other weld on the outside at the top of the base.

vi. Anchor bolts shall be of suitable diameter and length to develop full the ultimate strength of the pole. The upper ends of anchor bolt shall be threaded and furnished with hexagonal heads. The lower end of the bolt shall have ‘L’ bend of length not less than 3 times the diameter of bolt. The anchor bolts and nuts shall be hot dip galvanized as per technical provisions/ WAPDA Specification P-82:81/T.P. Metal covers shall be provided for covering the nuts and the portion of the bolt extending about the base and metal cover shall be attached to the steel base by means of cap screws.

2. Welding

i. All welds shall be performed i.e. works before galvanizing. All welding shall be Electric Arc according to some International Standards and shall include the following processes:

- Shielded metal arc welding
- Submerged arc welding
- Gas metal arc welding

a) The electrodes used shall be compatible with grade and chemical composition of the steel used and shall have mechanical properties at least equal to physical properties of the steel to be welded. Uncoated electrodes shall be used.

ii. The welds shall confirm to the following minimum requirements.

a) Longitudinal Welds i.e. (For poles and crossarms)

- 90% penetration of all thickness of sheet steel
- The weld shall be free from any inside and outside cracks
- No blow holes on the surface of the weld shall be allowed
- No surface blister shall be tolerated

b) Transverse Welds i.e. (For base plate)

- 100% penetration between sheet steel regardless of thickness considerations
- All welds shall be free from all cracks both inside and outside
- No blow holes on the outside of the weld
- The blisters, porosities, spherical inclusions exceeding 5% of the minimum thickness of the sheet steel shall be refused.
- The detectible angular inclusions shall not be tolerated

iii. In order to maintain the quality of the weld, manufacturer shall make use of the most adequate method and control instruments in order to verify the quality of completed weld: ultra-sonic or radio control methods (X or gamma rays) shall be used in the work.

3. <u>Galvanizing</u>

i. All parts of the poles and crossarms shall be hot dip galvanized after completion of manufacturing operations. No further manufacturing, touching up or modification shall be performed on the pole or crossarms after they have been galvanized.

ii. The galvanizing shall be performed on both inside and outside faces of pole and crossarms.

iii. The galvanizing of the relevant plate or sheet of steel used for the manufacturing of pole and crossarms shall be as per WAPDA Specification P-82:81/TP. However, the thickness of galvanization of poles and crossarms shall be as indicated on relevant drawings.

iv. The galvanization of nuts and bolts shall be as per WAPDA Specification P-82:81/TP.

IV. Accessories

1. <u>Sign Plates</u>

All poles shall be fitted with danger, number and phase plates in accordance with Drawing No.PDW/DF-207.The plates shall be fixed in accordance with drawing no.PDW/DF-207.The sign plates shall be fired ceramic surfaces on steel base plates the ceramic enamel shall completely cover the front and back of the interior edges of the attachment holes the enamel around the hole shall be protected by means of fiber washers.

2. <u>Removable Ladders</u>

Removable ladder of suitable step shall be provided as per Technical provisions however the spacing of the steps should not be more than 400mm/450mm.

<u>Anticlimbing Device</u>

The anticlimbing device shall consist of an arrangement of barbed wire around the pole to prevent un-authorized person from climbing the pole. It shall be made according to drawing no.GW/TZ-7.The outer most barbed wire shall be at least 600mm from the pole spacing of barbed wire shall not exceed 150mm. The anticlimbing device shall be fixed at about 3M from the ground level.

3. <u>Details for Attachment</u>

i. Provision shall be made for attachment of suspension and tension strings, overhead ground wire and the grounding rods.

ii. For attachment of ground wire, arrangement shall be made at the top for suspension and tension fittings for 9mm E/wire to accept assemblies as per drawing no.PDW/DF-319.

iii. For attachment of suspension or tension strings provision in the cross arm shall be made to accept assemblies as per drawing no. PDW/DF-314 & drawing no.PDW/DF-327.The suspension and tension string assembly shall be attached with the cross arm through the shackle drawing no. PDW/DF-478.

iv. In case of anchor base type poles, the grounding rods shall be attached to one of the anchor bolts by means of a copper cable of suitable length as shown on drawing no. EW/TC-42.

v. All ferrous hardware shall be hot dip galvanized as per WAPDA Specification P-82:81/T.P.

V. Tests

A. Manufacturer Tests

i. The manufacturer shall select two samples from each to carry out the following tests to satisfy himself that the products comply with this specification. The tests shall be performed as per WAPDA Specification P-139:80

For Steel

- Chemical Analysis
- Tensile Tests
- Bend Tests

For Nuts Bolts and Washers

- Tensile Strength Test
- Bend Test

The manufacturer shall maintain a record of tests carried out by him for examination by inspector/engineer.

B. Acceptance Tests

The following acceptance tests shall be carried out:

For Pole

- Visual Examination
- Verification of dimension and weights
- Prototype Test

For Nuts Bolts and Washers

- Verification of Dimensions (As per WAPDA Specification P-139)
- Visual Inspection
- Proof Load Test
- Ultimate Tensile Strength Test
- Galvanizing Test

- Bend Test

C. Visual Examination

The test samples shall be examined visually for the following:

Examination	Defects
Material	Not as specified in relevant clauses
Construction	Not of the shape indicated
Finish	Galvanizing not proper, presence of burrs, black and bare spots, dross and projection
Welding	Not as specified

D. Verification of Dimension and Weight

For conformity to the requirement of dimension and weight, in case the rejection number increases as specified in this specification, for the limits of tolerances mentioned in relevant clause. The entire lot shall be rejected.

E. Prototype Test

i. Full scale tests shall be carried out on each type of pole of maximum height as shown on the drawings, Different cases are to be tested to the ultimate design loads without failure. The pole shall then be tested to destruction. Load cases shall be specified by the Engineer at a later stage.

ii. The pole shall be erected on a foundation structure or anchored on bolts which shall be of adequate strength and stiffness to withstand safely the pole reactions under test loadings without any mobility. The foundation structure or anchor bolt arrangement should be such that as simulating the conditions which will be encountered in service.

iii. Each part of the pole and cross arm shall be of the same grade and class as those to be furnished for the specified poles of the same type.

iv. The poles to be tested shall be galvanized and in all respects identical to the poles to the supplied.

v. The testing bench shall be so designed as to prevent practically any introduction of appreciable error in measurement such as friction. For that purpose the measuring device used shall be placed in such a manner as to directly record the loads.

vi. Prior to testing, the contractor shall submit for approval of the Engineer a line diagram showing layout of the test site, rigging, location of load measuring instruments to be used and a series of line diagrams showing the loads to be applied, taking into account the weight of rigging and angle of load application. The contractor shall submit for approval a tabulated form on which the applied load and corresponding deflection readings will be entered for each load case.

vii. Testing bench at the test site shall be capable of handling ultimate loads with safety. Testing bench shall be capable of handling increased loads during destruction testing with adequate safety of personnel working on the test facility.

viii. The load monitoring equipment shall be electronic transducers complete with appropriate digital readout meters and recorders with an overall accuracy

±1%. All load monitoring equipment shall be calibrated before and after testing of the poles.

ix. The testing of pole shall be carried out in the presence of personnel of the Engineer.

x. QESCO shall be notified at least six weeks in advance of the date the tests are to be conducted. Time shall be allowed for the Engineer to approve the actual.

xi. The ultimate loads shall be applied. The drawings showings the combination of loads for testing shall be supplied by the Engineer at a later stage. The loads shall be applied in five steps of 50%, 75%, 90%, 95% and 100% of the ultimate loads. Each test loading shall be applied according to the drawings and maintained for not less than 5 minutes during which time there shall be no slacking for adjustment of the loads. Should it become necessary to adjust the loading, the 5 minutes period shall start after the loading, is stabilized and constant. All test loads shall be removed completely before the loads for the next test are applied. After each test load deformation due to longitudinal, transverse torque strain shall be measured (A 10% deformation residue of the maximum deformation recorded at the end of the pole due to the adjustment of the parts and to the remaining tension in the hoisting cables will be acceptable). All test loads corresponding to conductor and ground wire loading shall be applied directly to the regular attachment detailed provided for these loads. Test load equivalent to wind load on the pole shall be applied at the Centre of Gravity of the specified section of element, taking into account the drag coefficient as calculated according to IEC 60826. To ensure application of full test loads to the pole, friction losses in rigging shall be added to specified loads, if there is rigging between the pole and the load measuring device. Application of impact loads shall be avoided.

xii. Any conspicuous yielding or any failure under any of the above test loadings shall be considered a defect. If a defect develops because of faulty workmanship or materials, the contractor shall correct the defect and repeat the test loading at his own expense, including any additional cost incurred by client for the witnessing of the repeat test loading by the Engineer.

xiii. In the event of collapse of part under loads of a value lower than 95% of ultimate loads, the part that has collapsed may be replaced by another with greater mechanical strength. The modified structure shall be required to pass the test for the specified 100% ultimate load.

xiv. If the collapse of a part occurs at loads between those corresponding to the 95% and 100% of the ultimate loads, one of the following two procedures may be adopted:

a) The poles shall be tested according to the procedures as mentioned in clause E. xiii.

b) The test shall be repeated on another pole of the same batch and the structure shall be required to pass the 100% of the ultimate load as specified by the Engineer. Cost of repeating the test including cost incurred by the client for witnessing of the repeat tests by client/engineer shall be to the contractor's account.

F. <u>Sampling Plan-Acceptance and Rejection</u>

Sampling sizes are designated by code letters. Table-I shall be used to find the applicable code letter for the particular lot or batch size for various tests specified in this specification. While the number of units of product from each lot or batch which are to be inspected (sample size) and the criteria for determining the acceptability of the lot or batch (acceptance and rejection numbers) for different code letters can be obtained from the Table-II given below.

The number of sample units inspected shall be equal to the first sample size given in Table-II. If the number of defective units found in the first sample is equal to or less than the first acceptance number, the lot shall be acceptable. If the number of defectives found in the first sample is equal to is equal to or greater than the first rejection number, the lot shall be rejected. If the number of defectives found in the first sample is between the first acceptance and rejection number, second sample of the size given by the plan shall be inspected. The No defectives found in the first and the second samples shall be accumulated. If the cumulative No .of defectives is equal to or less than the second acceptance number the lot shall be acceptable. If the cumulative No. of defectives is equal to or greater than the second rejection number, the lot shall be rejected.

TABLE-I SAMPLE SIZE

Lot or Batch Size	Sample Size for Test Specified in Clause E	Sample Size for Dimensional and Finish Defects
2 to 8	A	A
9 to 15	A	B
16 to 25	A	C
26 to 50	A	D
51 to 90	B	E
91 to 150	B	F
151 to 280	B	G
281 to 500	C	H
501 to 1000	D	J

TABLE: II SAMPLE ACCEPTANCE CRITERIA

Sample Size Code Letters	Sample	Sample Size	Cumulative Sample Size	Acceptance Number	Rejection Number
A	First	1	1	0	1
	Second	-	-	-	-
B	First	2	2	0	2
	Second	2	4	1	2
C	First	3	3	0	2
	Second	3	6	1	2
D	First	5	5	0	2
	Second	5	10	1	2
E	First	8	8	0	2
	Second	8	16	1	2
F	First	13	13	0	3
	Second	13	26	3	4
G	First	20	20	1	4
	Second	20	40	4	5
H	First	32	32	2	5
	Second	32	64	6	7
J	First	50	50	3	7
	Second	50	100	8	9

VI. DRAWING AND DATA

1. The Contractor shall submit outline drawings and design drawing of steel poles as Indicated in clauses VI.2 to VI.6 with his bid. After placing of the contact the contractor shall submit for approval, drawings as indicated in paras VI.7 to VI.10 and any other calculation and drawings required by the Engineer.

2. The following information shall be supplied:

   I. Catalogues /Literature of standardized item.

   II. Test Certificate

   III. Detail of manufacturing welding and testing facilities available with manufactures

3. Material Details

   Information such as grade and standard of steel used giving ultimate tensile, minimum elongation, minimum yield strength, chemical composition of steel, standard and method of galvanizing, welding and method of fabrication of pole shall also be appended. English language copy of the particular standard according to which the steel is supplied, and the standard for all galvanizing, welding and other applicable steel shall be supplied with bid.

4. Outline Drawings

   Outline drawings for each type of pole and showing the size, location and arrangement of all elements, principal outline dimensions and conductor clearances to the poles, the size and length of elements shall be provided. It should be possible to verify the drag coefficient and weight of poles. Separate details to a large scale shall be shown for all insulator and ground wire connection. If necessary for clarification, a large scale shall also be used for plotting details.

5. Design Calculations and Stress Diagrams

   Design calculations and stress diagrams shall show the following information. Detailed calculations of wind loadings on pole shall be included. Loading calculations, bending moments, stress diagrams, section modulus, thicknesses, inside and outside diameter for each section or elements of pole.

   Design calculations if carried out by computer shall be fully documented. Full details of the analytical methods used shall be provided. Documentations shall provide a full explanation of the methods of programming and the interpretation of the detailed results.

6. Foundation Drawings and Calculations

   Fully dimensioned drawings of all foundations showing the volume of the foundations. Calculations showing the loads imposed on the foundations and the resultant bearing pressure and uplift resistance of the foundations.

7. Shop Detail Drawings

   Shop detail drawings showing all shop details including all dimensions slip joint or flanges, bevel cutting, bending and the identification mark and weight for each element. The contractor shall not proceed with the shop detail drawings until the outline drawings and design stress analysis have been approved by the Engineer.

8. Erection Drawings

Erection drawings showing each element or section with its identification mark, location and position of the outstanding pole element number and size of connection bolts and all erection details.

9. Footing Installation Drawings

Footing erection drawings showing embedded part with its identification mark or all dimensions required for the proper setting with lower and upper templates and positioning of anchor bolts with relation to the center of the pole.

10. Bills of Material

Enclosure:

1. Drawing. No. ENM/GTP-201
2. Drawing. No. ENM/GTP-202
3. Drawing. No. ENM/GTP-203
4. Drawing. No. PDW/ DF-207
5. Drawing. No. PDW/DF-314
6. Drawing. No. PDW/DF-319
7. Drawing. No. PDW/DF-327
8. Drawing. No. EW/TC-42
9. Drawing. No.GW/TZ-07
10. Drawing. No. PDW/DF-478

8.2.2.2 **132kV Pole Type SP-AC, SP-DC & SP-GC**

The transmission line poles shall consist of a galvanized steel pole having base plate with six cross arms. The pole and cross arms shall be of polygonal shape and tapered uniformly. The assembly of all sections shall be achieved by slip joints.

The type of 132kV steel poles shall be as under:

SP-AC	Suspension Pole	Upto 2^0
SP-DC	Medium Angle Pole	Upto 30^0
SP-GC	Heavy Angle Pole	Upto 60^0 and Terminal Pole

i. Suspension Pole Type SP-AC

The pole shall be manufactured and supplied as per drawing no.SP-AC-00(Page 1 & 2) and in accordance with WAPDA specification P-166:83/T.P with high strength anchor bolts, nuts washer etc, upper and lower templates, removable ladders and its hinges/ brackets shall also be provided on pole shaft. The galvanization of poles shall be carried out in accordance with clause 5 of technical provisions and WAPDA specification P-82:81. The material of pole and cross arms shall be in accordance with ASTM-572 Grade 65- or equivalent.

ii. Medium Angle Pole Type SP-DC

The pole shall be manufactured and supplied as per drawing no.SP-DC-00 (Page 1 & 2)and in accordance with WAPDA specification P-166:83/T.P with high strength anchor bolts, nuts washer etc, upper and lower templates, removable ladders and its hinges/ brackets shall also be provided on pole shaft. The galvanization of poles shall be carried out in accordance with clause 5 of technical provisions and WAPDA specification P-82:81. The material of pole and cross arms shall be in accordance with ASTM-572 Grade 65- or equivalent.

iii. Heavy Angle Pole Type SP-GC

The poles shall be manufactured and supplied as per drawing no.SP-GC-00(Page 1 & 2) and in accordance with WAPDA specification P-166:83/T.P with high strength anchor bolts, nuts washer etc, upper and lower templates, removable ladders and its hinges/ brackets shall also be provided on pole shaft. The galvanization of poles shall be carried out in accordance with clause 5 of technical provisions and WAPDA specification P-82:81. The material of pole and cross arms shall be in accordance with ASTM-572 Grade 65- or equivalent.

9. CONDUCTOR

All Aluminium Alloy Conductor AASC Greeley shall be used as per WAPDA/ NTDC Specification P-117:88 (Copy enclosed) having the following main characteristics.

Conductor Diameter(mm)	28.14
Stranding/Diameter of each Wire(No/mm)	37/4.02
Nominal Weight(kg/km)	1289
Ultimate Rated Strength (kg)	13835
Cross Section Area(mm^2)	469.80
Max D.C Resistance at 20°C (Ohm/km)	0.0713
Nominal Reel Length(km)	3.20

10. HARDWARE FOR AASC (GREELEY)

10.1 *SINGLE SUSPENSION STRING*

Suspension string for AASC Greeley Conductor shall be as per WAPDA/NTDC specification P-140:82 (copy enclosed) except the following main features/characteristics:

i. The single suspension string for AASC Greeley string shall be suitable for 28.14mm overall diameter of conductor & shall be designated as SS-G.

ii. The first letter ‘S’ Stand for single, the next letter ‘S’ stand for suspension and the succeeding letter stand for the name of conductor for which the hardware is meant for i.e. ‘G’ for GREELEY.

iii. The failing loads, dimension and tolerances of each component of hardware of suspension string of AASC Greeley shall correspond to SS-R.

10.2 *SINGLE TENSION STRING*

Tension string for AASC Greeley Conductor shall be as per WAPDA/NTDC specification P-143:82 (copy enclosed) except the following main features/characteristics:

i. The single tension string for AASC Greeley Conductor shall be suitable for 28.14mm overall diameter of conductor & shall be designated as ST-G.

ii. The first letter ‘S’ stand for single, the next letter ‘T’ stand for Tension and the succeeding letter stand for the name of conductor for which the hardware is meant for i-e ‘G’ for GREELEY.

iii. The tension clamp for AASC Greeley Conductor shall be of compression dead end type. It shall be composed of aluminum body with one jumper lug, one galvanized steel terminal and one aluminium jumper terminal with galvanized steel bolts. The aluminum jumper terminal shall be at 30^0 and shall be supplied with bolts, nuts, corrosion resistant aluminum alloy washers and spring washers.

iv. The clamp when assembled shall be capable of developing not less than 95% of the rated minimum failing load i-e the ultimate tensile strength of the conductor and has conductivity not less than that of conductor whereas the failing loads, dimension and tolerances of other each component of hardware of tension string of AASC Greeley shall correspond to ST-R.

10.3 *SINGLE JUMPER STRING*

Jumper string shall be suitable for 28.14mm diameter conductor and shall be used with heavy angle towers/poles i.e. ZM60^0, ZM60^0 (Modified), WPD, SPG, SPH-C & SP-GC. Fixing arrangement of jumper string with these tower types shall be ensured by the manufacturer. The failing load dimension & tolerances of jumper string shall be as per SS-R.

10.4 *MID SPAN JOINT AND REPAIR SLEEVE*

i. Mid span joint and repair sleeve for AASC Greeley Conductor shall be as per WAPDA/NTDC specification P-144:80 (copy enclosed) except the following main features/Characteristics.

ii. The Mid span joint and repair sleeve for AASC Greeley Conductor shall be suitable for 28.14mm overall diameter of conductor & shall be designated as MS-G. Whereas repair sleeve shall be designated as RS-G.

iii. The first two letter stand for mid span joint or repair sleeve i.e. MS for mid span joint and RS for repair sleeve.

iv. The next letter stands for the name of conductor for which hardware is meant for i.e. 'G' for GREELEY**.**

v. Mid span joint shall be one piece of aluminum alloy sleeve and shall be suitable for one step compression and shall be such that after compression it shall assume a hexagonal shape.

vi. The failing load of MS-G shall be consider as ultimate tensile strength of conductor AASC Greeley. The joint shall develop at least 95% of the ultimate strength of conductor.

vii. Repair sleeve shall be of aluminum alloy open type, consisting of body and keeper, which interlock when compressed. The repair sleeve should restore 95% of the conductor ultimate strength with the condition when no more than 1/3 of the aluminum stands are damaged.

viii. Conductor compression dies shall be suitable for use on accessories of 927.2 KCM AASC "Greeley" conductor. The dies shall be of steel having hexagonal configuration. The design of all compression fittings shall be such that only one pair of dies is necessary for one conductor type. The dies should be compatible with type of compressors and accessories being supplied.

In addition each die cavity will be imprinted with Die section/identification number so that the same is embossed on the compression fitting each time, a crimp is made. The supplier shall provide the detailed drawings along with the dies material properties for approval.

10.5 <u>STOCK BRIDGE VIBRATION DAMPERS</u>

The Stock Bridge Vibration Dampers shall be as per WAPDA/NTDC specification P-142:83 (copy enclosed) except the following main characteristics.

Material of Damper Weights	High quality Corrosion Resistant Metal Alloy
Material Clamp	Aluminium Alloy
Material of Messenger wire bolts, Nuts & Washers	A)High tensile galvanized steel(Line #7) B)High Quality Stainless Steel(Line# 8)
No. of Dampers per span of 300 meters	2 (One Damper at each end of span)
Additional type and sample tests to be carried out	(i) Clamp Slippage Test (ii) Bolt Torque (iii) Corona Test

11. (a) INSULATORS (Applicable For Line#7)

i. Porcelain type, Ball + Socket Coupling Fog Type Insulators shall be used as per WAPDA/NTDC specification P-8:96 (Copy attached) with straight headed design and corrosion intercepting Zinc sleeve having the following main characteristics:

Description	Line no. 7	Line no. 7
Type Designation	U80BLF	U120BLF
Disc Diameter (mm)	255	255
Disc Spacing (mm)	146	146
Min Creepage Distance (mm)	430	430
Standard Couple Pin Diameter (mm)	16	16
E & M Strength (kN)	80	120
Galvanizing Coating(Cap & Pin):		
a) Individual Sampling(g/m^2)	1050	1050
b) Average of 3 Samples(g/m^2)	1080	1080

(b) INSULATORS (Applicable For Line #8)

i. RTV Coated Porcelain type, Ball + Socket Coupling Fog Type Insulators shall be used as per Technical provisions, WAPDA/NTDC specification including latest amendments with straight headed design and corrosion intercepting Zinc sleeve having the following main characteristics:

Description	Line no. 8 "ZONE A"	Line no. 8 "ZONE A"	Line no. 8 "ZONE A"
Type Designation	U80BLF	U100BLF	U120BLF
Disc Diameter (mm)	280	280	280
Disc Spacing (mm)	146	146	146
Min Creepage Distance (mm)	470	470	470
Standard Couple Pin Diameter (mm)	16	16	16
E & M Strength (kN)	80	100	120
Galvanizing Coating(Cap & Pin):			
a) Individual Sampling(g/m^2)	1050	1050	1050
b) Average of 3 Samples(g/m^2)	1080	1080	1080
RTV Coating(Cap & Pin)	As Per Specification	As Per Specification	As Per Specification

ii. Porcelain type, Ball + Socket Coupling Fog Type Insulators shall be used as per WAPDA/NTDC specification P-8:96 (Copy attached) with straight headed design and corrosion intercepting Zinc sleeve having the following main characteristics:

Description	Line no. 8 “ZONE B”	Line no. 8 “ZONE B”	Line no. 8 “ZONE B”
Type Designation	U80BLF	U100BLF	U120BLF
Disc Diameter (mm)	280	280	280
Disc Spacing (mm)	146	146	146
Min Creepage Distance (mm)	470	470	470
Standard Couple Pin Diameter (mm)	16	16	16
E & M Strength (kN)	80	100	120
Galvanizing Coating(Cap & Pin):			
a) Individual Sampling(g/m^2)	1050	1050	1050
b) Average of 3 Samples(g/m^2)	1080	1080	1080

12. ALUMOWELD SHEILD WIRE (AWS)

The following entail the basic requirement of alumoweld overhead shield wire properties, characteristics, stranding and its manufacturing.

12.1 SHIELD WIRE CHARACTERISTICS

The overhead shield wire shall be in accordance with ASTM B-416 and before stranding the aluminum-clad steel wires shall meet all the requirements of Specifications B-415 (20.3% conductivity only) plus the following requirements.

Size Designation	7 # 8 AWG
Diameter of alumoweld shield wire(mm)	9.78
Number of strands of wire	7
Diameter of each strand(mm)	3.26
Nominal weight of the wire(kg/km)	390
Rated Ultimate Tensile Strength(kg)	7226
Cross- Sectional Area(mm^2)	58.56
Nominal D.C Resistance at 20^{o}C (Ohm/km)	1.463
Nominal Reel Length(km)	2.0

12.2 *JOINTS*

There shall be no joints of any kind made in the finished strand entering into construction of alumoweld overhead shield wire. Welding before cold drawing of the strand may be made in accordance with ASTM B416 latest edition.

12.3 *STRANDING*

The lay factors used shall be within the limits specified in the ASTM B416. Once stranding has been started, the same lay factor shall be maintained for all wire shipments. The wire shall be stranded in one pass.

12.4 *TENSILE STRENGTH AND ELONGATION OF WIRE AND OTHER TESTS*

The supplier shall test complete sections of the individual wire and complete conductor follow the procedure as laid down in the relevant ASTM B415 and B416 respectively The pieces of wire to be tested shall be cut off from reels arbitrarily selected by the Engineer but not more than 2 reels out of every 15 will be chosen unless a production run produces less than 15 reels of wire. In that case, the Engineer reserves the right to test 2 samples from each production run of less than 15 reels, and if the wire or strand fails in the first test to meet any requirement of this Specification, further samples shall be tested from reels numbered, x, x+10 & x-10 where x is the reel number from which the rejected sample was taken. If these three samples meet the specification, the lot shall be accepted. If one of the last three samples does not meet the specification, samples shall be tested from reels x+5 & x-5 where x is the reel number from which the sample that did not meet the specification was taken.

This process shall be repeated until all reels containing faulty material have been located and rejected.

The wire shall also withstand twist test as given in the relevant ASTM standards (latest edition).

The number of samples of alumoweld wire shall be tested in accordance to the tests specified in ASTM B415.

The strength and elongation test shall be done by obtaining stress-strain curves of the sample to determine that the requirements of ASTM Standards are met. This test shall be done to destruction.

12.5 *SUPPLY OF STRESS-STRAIN CURVES*

The Supplier shall supply the initial and final stress-strain curves, for the overhead shield wire.

12.6 MARKINGS AND PACKING

Each end of the overhead shield wire (SW) in the reel shall bear a non-corrosive tag identifying the following:

a. Type of SW

b. Diameter/Size of SW

c. Minimum Breaking Strength

d. Length of SW

e. Stranding

Each reel shall be stenciled or provided with metal plates to show all information under the above paragraph plus additional information as follows:

a. Manufacturer's Name and Country of Origin

b. Year of Manufacture

c. Reel Number

d. Size of Reel

e. Gross Weight

f. Net Weight

g. Consignee Address

h. Direction of Rolling

All markings shall appear on both sides of the reel.

The overhead shield wire shall be furnished on non-returnable wooden reels, protected by wood lagging or other suitable method against damage during shipment and to facilitate field handling and long-term outdoor storage. However it is the responsibility of the supplier that the method of packing shall be strong enough to withstand wear and tear during sea/inland transportation and handling at site.

However, the manufacturer may at his own option furnish the shield wire on nonreturnable steel reels at no additional cost to the purchaser.

Methods of packaging, marking and shipping shall be submitted to the Engineer for review and acceptance.

13. HARDWARE FOR ALUMOWELD SHIELD WIRE

13.1 SUSPENSION FITTING (For AWS)

The general arrangement of suspension fitting shall be as shown on drawing no. PDW/DF-320 of WAPDA specification P-141.The suspension clamps shall be suitable for 9.78 mm overall diameter of alumoweld shield wire. The clamp used for suspension fitting shall consist of following items:

13.1.1 Body and Keeper

The bodies and keepers of ground wire suspension clamps shall be made of high strength corrosion resistant aluminum alloy and the cotter pins shall be of stainless steel. The **SPLIT PIN** to be used as locking device shall be made from stainless steel to be protected against corrosion.

13.2 *TENSION FITTING (For AWS)*

The general arrangement of tension fitting shall be as shown on drawing no. PDW/DF-319 of WAPDA specification P-141.The tension clamps shall be suitable for 9.78mm overall diameter of alumoweld shield wire. The assembly shall develop 95 percent of the full rated strength of the overhead shield wire. Under this condition the overhead shield wire shall not slip through the clamp after final makeup of the assembly, and there shall be no permanent deformation on any of the components of the assembly when subjected to slippage test.

The clamp used for tension fitting shall consist of following items:

13.2.1 Earth Wire Tension Clamp

These clamps shall be made from high strength corrosion resistance aluminium alloy and shall be suitable for clamping shield wire without having to cut it. The clamp shall be a bent-leg bolted type with provisions for attachment of pulling fittings for erection and maintenance in accordance with drawing no PDW/DF-328 and having minimum failing load of 8000kg.

13.2.2 Earthing Clamp

These clamp shall be made from high tension corrosion resistance aluminium alloy and shall be in accordance with drawing no. PDW/DF-321 of WAPDA speciation P-141.

13.2.3 Shackle

These shall be made from forged steel hot dip galvanized and shall be in accordance with drawing no. PDW/DF-321 of WAPDA specification P-141.The connection of shackle with bolted type tension clamp shall be achieved by adding an eye link to form a tension assembly having a minimum failing load of 8000kg.The manufacturer shall submit tension assembly drawing of AWS before manufacture for the approval of consultant.

13.3 *MID SPAN JOINT (For AWS)*

The mid span joint shall be suitable for 9.78 mm overall diameter of alumoweld shield wire. This joint shall be in accordance with drawing no PDW/DF-321 of WAPDA specification P-141. The splice for overhead shield wire (mid span joint) shall be a one part aluminium alloy sleeve with open mouth and when compressed will grip the shield wire, assume hexagonal shape cross section and develop 95% of full rated strength of shield wire. The conductivity of the mid span joint shall be equal to the conductivity of shield wire. The mid span joint shall withstand the high current caused by lightning. On each mid span joint, catalog number, die size and diameter of shield wire shall be stamped.

13.4 STOCK BRIDGE VIBRATION DAMPERS (For AWS)

The Stock Bridge Vibration Dampers shall be suitable for 9.78 mm overall diameter of alumoweld shield wire as per WAPDA/NTDC specification P-142:83 (copy enclosed).The clamp shall be made of high strength aluminium alloy.

14. GROUNDING MATERIAL

The grounding material to be used for steel towers and steel poles shall be in accordance with WAPDA/NTDC specification P-16:68 and P-116:81 (copy enclosed) with earthing arrangement shown on drawing no. EW/TC-42(copy enclosed).The copper weld/copper cover shall be of uniform thickness not less than 0.38mm for copper weld and 0.45mm for copper bonded process/electrolytically deposited process.

The components of grounding material and its characteristics shall be as follows:

Grounding Rod	3M long copper weld/copper cover rod of 16mm diameter
Solid Copper Wire	1M long,6.5 mm diameter
Connectors:	
a) Clamp(rod to wire connector)	Bronze clamp with non-ferrous safety sets screw
b) Terminal(Wire to stub angle connector)	Copper alloy compressed terminal

15. 60 TON HYDRAULIC COMPRESSORS (ENGINE DRIVEN)

The hydraulic compressor shall be of portable type supplied with hydraulic power pump (with gasoline engine drive). The compressor shall be of latest model equipped with an integral hinged head with eyes suitable for hot line maintenance work. The compressor shall be supplied with ground stand and steel carrying case. The design of compressor shall be coordinated with the design of accessories. The compressor shall develop a thrust of 60 tons at a nominal pressure of 700 kg/cm^2. The above would include 5 m long low and very high pressure hoses along with necessary adaptors, fittings compatible with the actual site temperature and pressure gauge (range 0 - 1000 kg/cm^2). The working temperature range shall be –10°C ~ 55°C.

16. 100 TON HYDRAULIC COMPRESSORS (ENGINE DRIVEN)

The hydraulic compressor shall be supplied with hydraulic power pump (with gasoline engine drive). The compressor shall be of latest model equipped with an integral hinged head with eyes suitable for hot line maintenance work and capable of being operated remotely. The compressor shall be supplied with ground stand and shipping steel case. The design of compressor shall be coordinated with the design of accessories. The compressor shall develop a thrust of 100 tons at a nominal pressure of 700 kg/cm^2. The above would include 10 m long, low and very high pressure hoses along with necessary adaptors, fittings compatible with the actual site temperature and pressure gauge (range 0 - 1000 kg/cm^2). The working temperature range shall be -10°C ~ 55°C.

COMPRESSION DIES FOR AASC AND SHIELD WIRE

Conductor compression dies shall be suitable for use on accessories of 927.2 KCM AASC “GREELEY” Conductor. The dies shall be of steel having hexagonal configuration. The design of all compression fittings shall be such that only one pair of dies is necessary for one conductor type.

Shield wire compression dies shall be suitable for use on accessories of 9.78 mm dia, 7 strands alumoweld overhead shield wire. The dies shall be of steel having hexagonal configuration.

The dies (conductor & shield wire) should be compatible with type of compressors and accessories being supplied.

In addition each die cavity will be imprinted with die section/identification number so that the same is embossed on the compression fitting each time a crimp is made.

The supplier shall provide the detailed drawings along with the dies material properties for approval.

17. FILLER COMPOUND

The filler compound shall be of suitable material to be used as filler for compression accessories. The filler should effectively seal out the compression fitting against air and moisture. The filler compound shall be supplied in a package/carton of hundred (100) tubes each having 0.5 kg filler weight.

18. ELECTRICAL JOINT COMPOUND

The electrical joint compound shall be of suitable material to be used for making aluminum-to-aluminum & flat-to-flat surface contacts such as terminal to dead end. The compound shall be an active chemical in a grease type sealer and shall act to dissolve the oxide film and seal the joint against moisture. The flow point of the compound shall not be less than 100°C. The flash point should not be less 190^{0}C and alkalinity/basicity < 0.1%. The compound shall be supplied in a package/carton of 10 tubes each having 0.25 kg compound weight.

19. ADDITIONAL TEST

The purchaser/client reserves the right for carrying out any other tests of a reasonable nature at the works of the supplier/laboratory or at any other recognized laboratory/research institute in addition to the above mentioned type, acceptance and routine tests at the cost of the purchaser to satisfy that the material complies with the intent of this specification.

20. CO-ORDINATION FOR TESTING

For insulator strings, the supplier shall arrange to conduct testing of their Disc/Porcelain insulators with the hardware fittings to be supplied to the purchaser/client by other suppliers. The supplier is also required to guarantee overall satisfactory performance of the Disc/Porcelain insulator with the hardware fittings.

21. NOTE

In respect of electrical tests on a complete string consisting of insulators and hardware guarantee of values of responsibility of testing shall be with hardware manufacturer of RIV, corona and voltage distribution test (Applicable of Disc insulator strings only) and with insulator manufacturer for all other tests.

22. RTV SILICON RUBBER COATING ON INSULATORS

The RTV coated insulators shall be supplied as per latest WAPDA/NTDC Specifications including all amendments to date. Following is the Technical Provision of RTV coatings on Fog type Insulators.

22.1 RATINGS

1. The RTV Silicone Rubber HVIC shall have the following properties as supplied:

Property	Value
Basic Component	HVIC, RTV silicone coating containing Alumina Tri Hydrate (ATH)
Type	One-Part, RTV
Appearance	Paint
Colour	White, Grey or any other subject to Engineer's Approval
Specific Gravity	1.10 to 1.25
Application Temperature Range	5ºC to 60ºC
Skin Over time at 25ºC and 50% relative humidity	15 minutes
Track free time at 25ºC and 50% relative humidity	15 to 45 minutes
Percent of Solids by weight	≥ 70%
Dynamic Viscosity, CP (centipoise)	1000 to 3500

2. The RTV Silicone Rubber HVIC shall have the following properties as cured at standard conditions (i.e. 25ºC temperature and 50% relative humidity) after seven (7) days:

Property	Value
Method of Application	Spray/Dip
Coating Thickness	380 - 500 micron
Dielectric Strength (ASTM D149)	350 to 560 V/mil, minimum
Volume Resistivity (ASTM D257)	$1x10^{14}$ to $37x10^{14}$ Ohm.cm
Dissipation Factor at 100Hz (ASTM D150)	0.01 to 0.09
Tracking Wheel Withstand	1000 hours, minimum
Receding Water Contact Angle	>80 degrees, minimum

Dry Arc Resistance	180 to 200 , Track Seconds
Tracking & Erosion Resistance (IEC 60587)	Minimum grade 1A 4.5
Loss Tangent	<0.6%
Warranty Period	10 years minimum from date of application. No preventive maintenance shall be required during the period.

3. The RTV Silicone Rubber Insulator Coating shall have hydrophobicity of silicone rubber material classified Wettability Class I (WC-I) or better as per IEC 62073. Accordingly, receding water contact angle shall be 80 degree or more.

22.2 MATERIALS

i. The RTV Silicone Rubber Insulator Coating shall have a chemical structure of 100 percent silicone rubber with highest possible concentration of Low Molecular Weight silicone chains (LMW) before fillers are added. The finished product shall be ultraviolet (UV) radiation exposure resistant. The finished product and its life shall be unaffected by atmospheric conditions due to weather, proximity to the coast, fumes, ozone, acids (particularly nitric acid present in the coastal area and sulfuric acid present in the prevailing environment of oil field areas in the region), bases/alkalis, and hydrocarbon components, dust or rapid changes to air temperature (temperature extremes). There shall be no material degradation such as development of surface cracks and increase in surface hardness, etc.

ii. The RTV Silicone Rubber Insulator coating shall be resistant to atmospheric and chemical degradation. Salt air, airborne pollutants, industrial pollutants such as cement dust or sulfur and rain or humidity shall not affect the coating.

iii. The RTV Silicone Rubber Insulator Coating shall be resistant to arcing and corona. The coating shall exhibit high tracking resistance to reduce damage during salt-storms (storms arising from the sea) or other severe contamination events. The track resistance or the RTV Silicone Rubber Insulator Coating material shall meet the requirements of IEC 60587, Method 1, Class 1A 4.5.

iv. The material of RTV Silicone Rubber Insulator Coating shall be room temperature vulcanized silicone rubber and shall have a Shore ‘A’ hardness of not less than 60.

v. The RTV Silicone Rubber Insulator Coating shall be applied by spraying or dipping to have the dry film thickness (DFT) of 0.38mm to 0.5mm in maximum three (3) coats of application.

vi. The RTV Silicone Rubber Insulator Coating shall be a single component, ready-to-use, and shall not require excessive mixing/shaking before use. However, depending on the application equipment, the humidity and the temperature conditions, thinning/dilution may be required. The manufacturer may be required to supply the suitable thinner and submit a table showing percentage (%) quantity to be used at different temperatures and humidity levels. The thinner shall be of high flash point. The coating shall be moisture curable at room temperature.

vii. The RTV Silicone Rubber Insulator Coating shall exhibit long-term water repellency and hydrophobicity.

viii. The RTV Silicone Rubber Insulator Coating shall not require use of any primer on the ceramic insulators for adhesion purposes.

ix. The RTV Silicone Rubber Insulator Coating shall be easy to be removed and reapplied. The Coating shall have excellent arc resistance, excellent unprimed adhesion, easy to apply and spray-able as well as dip-able.

x. The RTV Silicone Rubber Insulator Coating shall have minimum of 12 months shelf life, which shall effect from the date of manufacturing. The contractor shall submit the warranty to this effect. The expiry date shall be marked on the containers. The delivery of the material shall not take a long time and the material shall not be supplied from the old stock.

22.3 COMPOSITION AND PROPERTIES

i. The RTV Silicone Rubber Insulator Coating shall be One-part RTV silicone rubber made from a basic polydimethyl siloxane (PDMS) polymer system, which may contain a fumed silica reinforcer, a polymerization/condensation catalyst, cross-linking agent, UV resistant absorbent and alumina trihydrate (ATH) filler, adhesion promoter, all dispersed in a carrier solvent. Unless otherwise specified in the data schedule, the solvent shall be non-flammable type suitable for energized applications.

ii. The RTV Silicone Rubber Insulator Coating shall have the optimum filler particle size and optimum filler concentration to provide even and stable dispersion in the polymer for peak performance and extended shelf life.

iii. The solvent to be used in the RTV Silicone Rubber Insulator Coating shall be soluble with the polymers and shall have a good evaporation rate to provide speedy curing and have a purity to comply with all safety and environmental regulations. Manufacturer shall specify and provide the technical data of the dilution solvent, if thinning is required.

iv. The cure system (cross-linker and catalyst) shall be compatible with the filler for best performance and shelf life.

v. The manufacturer shall advise/recommend suitable method of application and provide written application instructions.

vi. The contractor shall submit in the data schedule the number of coats for dip application as well as for spray application to obtain the desired coating thickness in the range of 0.38mm to 0.50mm.

vii. The RTV Silicone Rubber Insulator Coating shall be capable of withstanding high-pressure power washing. To prove this property, a power wash test shall be performed.

viii. The RTV Silicone Rubber Insulator Coating shall protect the ceramic insulators against flashovers caused by pollution.

ix. The contractor shall provide warranty that the coating manufactured shall prevent insulator surface contamination based flashovers for a period of 10 years minimum at contamination ESDD (Equivalent Salt Deposit Density) level of the area specified.

22.4 MARKING

i. The packing and delivery dates of coating shall be labeled on the coating cans. The expiry date shall be considered from packaging date and not from the date of shipment of the coating.

ii. The cans shall be marked for “flammable” or “non-flammable” depending upon the type of solvent used for dispersion of the coating.

22.5 QUALITY ASSURANCE MECHANISM

i. The manufacturer should be ISO 9001 certified and shall invariably furnish following information along with his bid, failing which his bid may be rejected.

ii. Statement giving list of important raw materials, proposed to be used in the manufacture of the material against this specification, names of sub suppliers for the raw materials, list of standards according to which the raw materials are tested.

iii. List tests normally carried out on raw materials in presence of supplier's representative as routine and/or acceptance during production and on furnished goods, copies of test certificates.

iv. Information and copies of test certificates in respect of bought out accessories.

v. List of manufacturing facilities available.

vi. Level of automation achieved and list of areas where manual processing exists.

vii. List of areas in manufacturing process, where stage inspections are normally carried out for quality control and details of such tests and inspections.

viii. List of testing equipment available with supplier for final testing as specified. In case if the supplier does not possess al the routine and acceptance testing facilities the bid will be rejected.

ix. Special features provided to make it maintenance free.

x. QESCO reserves the right for factory inspection to verify the facts quoted in the bid. If any of the facts are found to be misleading or incorrect the bid of that supplier will be out rightly rejected and they may be black listed as per QESCO/NTDC's SOP.

22.6 APPLICATION OF RTV COATING

i. Before application of the RTV coating, the surface of the dielectric/porcelain shell shall be carefully cleaned and prepared, in order to ensure perfect bonding. High-pressure water washing/cleaning method will be used to remove common contaminants, such as accumulated dust and salt. More tenacious contaminants, such as cement dust may require a dry abrasive cleaner, such as ground corncob. The surface is then hand wiped with cloth rags and oil-less solvent to remove all contaminants. The process may be monitored by QESCO representatives.

ii. All surfaces must be clean and dry to ensure proper adhesion of RTV to the insulator surface.

iii. The coating shall be applied through an automated process assuring the uniformity and thickness of coating as well as the homogeneity of the surface. The RTV surface must become tack free before application of subsequent coats. The curing shall be done under well-controlled environmental conditions – humidity and temperature.

iv. The layer of RTV coating shall be strongly bonded to the surface of the dielectric/porcelain shell, in such way that it shall not be possible to peel it off. The coating shall be compatible with high-pressure washing.

v. The zinc sleeve of the pin of insulator shall not be coated with RTV silicone. The base of the cap shall be coated to a height of 0.5 to 1cm in the zone near to the porcelain shell.

22.7 INSPECTION AND TESTING

All test results shall be provided for review and acceptance by purchaser

22.8 ROUTINE TESTS

All routine (Production) tests prescribed in the relevant IEC Standards shall be performed prior to delivery to QESCO/Consultant, to eliminate manufacturing defects.

22.9 SAMPLE TESTS

The sample tests shall be carried out on the RTV coated insulators at manufacturer's own laboratory in the presence of QESCO/Consultant representatives or at an accredited Independent Test Laboratory or any other place agreed with purchaser.

22.10 RULES FOR INSULATOR SAMPLING AND THEIR DISTRIBUTION FOR TESTS

For sample tests, insulators shall be offered in lots of 10,000 units. The insulators intended for the sample tests shall be taken at random from each lot by the inspector after performing routine tests and elimination of any defective insulator.

The number "n" of insulators to be selected is indicated in Table-III below:

Table-III

Number of insulators selected from each lot(n)	Number of insulators in the 1st partial sample(n1)	Number of insulators in the 2nd partial sample(n2)
18	12	6

The total sample of 'n' insulators is further divided into two partial samples composed of "n1" and "n2" insulators.
The sample of "n1" insulators is subjected to the following tests as described in this specification:

I. Visual Examination
II. Dry Film Thickness Test
III. Adherence Test
IV. Hydrophobicity Test
V. Contact Angle Measurement Test

The sample of "n2" insulators is subjected to the following tests as described in this specification:

I. Visual Examination
II. Wet Film Thickness Test
III. High Pressure Water Withstand Test
IV. Boiling Water Test

22.11 VISUAL EXAMINATION

Visual inspection will be carried out in order to ensure:

I. **Smoothness & Uniformity:**

Coating should be contiguous, uniform, smooth and free of bubbles, water blisters, icicles, lumps and runs. The material shall flow sufficiently on insulator surface during application, amalgamating to form a smooth continuous finish yet not to flow too much on vertical surfaces resulting in drips and icicles of coating along the ribs of insulator sheds.

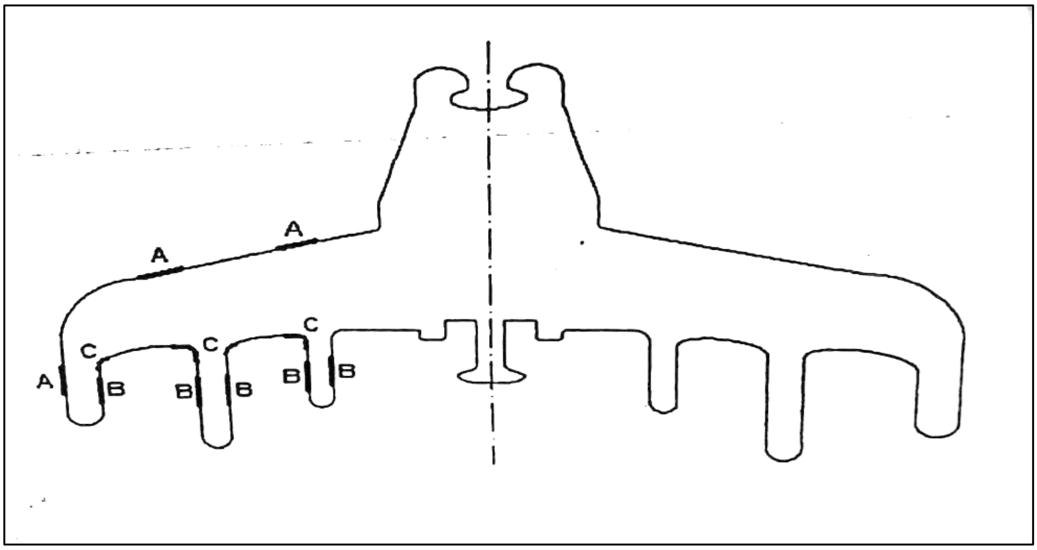
II. **Purity:**

Coating material should be free from any contaminant, impurity like metal parts, cement, dust etc. to prevent channeling of leakage current and dry band arcing.

22.12 THICKNESS TEST

1 Dry Film Thickness Test

Ultrasonic thickness Gauges will be used to read the thickness of cured silicone coating on porcelain surfaces. The gauges shall be calibrated and checked prior to its use. The measurement shall be performed at nine (9) different positions at the surface of insulator on the below part as well as upper part. On drawing below, areas where these measurements have to be performed are shown.



Alternately, three samples will be cut with a flat blade on the three 120° directions on the upper surface as noted 'A' and underneath surface noted 'B'. The measurement of the thickness will be performed with the magnetic method by interposing between a metallic support and the apparatus, the slice of coating to be measured.

The results are correct if

- The average A values is above 350µm and below 530µm.
- The average B values is above 280µm and below 380µm.
- The values of thickness could be lower on the C areas but applied regularly.

2 Wet Film Thickness Test

Wet Film gauges will be used to check wet film thickness after application of each coat on insulator. To determine the dry film thickness, percentage of solvent would be subtracted. For example, 0.5mm of wet material at 70% solids would provide 0.35mm of cured coating.

3 High Pressure Water Withstand Test

A power water wash test shall be performed in accordance with IEEE Std. 957TM to demonstrate that the RTV coated insulators can be power washed without any damage to RTV coating. The test shall be a water spray of a solid stream through a 6mm diameter nozzle at 3800 kPa for a period of ten (10) minutes. The nozzle of the spray equipment shall be at a distance of 3m from the insulator surface.

There shall be no signs of water penetration in between RTV silicone rubber coating and insulator surface.

4 Boiling Water Test

Boiling water test shall be performed in accordance with IEEE Std. 1523-2002 to verify the bonding characteristics of the RTV Silicone Rubber Coating when applied to ceramic insulators. The coated insulator shall be put in water and boiled for 100 hours and removed. The coating shall not exhibit water blisters at the interface between the insulator surface and the coating.

5 Adherence Test

The adherence test will be performed with specific tool described in standard EN-ISO 2409. Orthogonal traces and parallel traces shall be made. The measurement will be performed on two opposite sides of the upper surface of the same insulator. The adherence on the extremity of the under-ribs shall be controlled by scrapping off a strip along half the circumstances with cutter blade. The layer of silicone shall be adherent, uncoated porcelain/dielectric shell shall not be apparent.

6 Hydrophobicity Test

Hydrophobicity Test shall be carried out as per Annexure A (Hydro Classification Guide) of IEEE Std. 1523-2002.

7 Contact Angle Measurement Test

Contact Angle Measurement Test shall be performed in accordance with IEC 62073.

22.13 TYPE TESTS

All type tests mentioned below and in schedule of technical data should have been completed at an independent STL Lab/Lab named in NTDC's Type Test Policy.

I. Inclined Plane Tracking and Erosion Test as per IEC 60587
II. Accelerated Ageing Test (1000 Hours) as per IEC 61109
III. Artificial Pollution Test by Salt Fog Method as per IEC 60507
IV. Angle of Hydrophobicity as per IEC TS 62073
V. Hydrophobicity Recovery by Corona Test
VI. Dry Arc Resistance as per ASTM D495
VII. Dielectric Strength Test as per ASTM D149a
VIII. Volume & Surface Resistivity Test as per ASTM D257
IX. Dissipation Factor Test as per ASTM D150
X. Accelerated weathering test as per ISO 4892.

22.14 APPROVED LABS FOR RESPECTIVE TESTS

SCOPE OF TYPE TESTS	APPROVED LABS
CONDUCTOR	
1. Corona /RIV Test 2. Creep Test 3. Longitudinal Smoothness Test 4. Stress- Strain Test	Any lab as per Annexure-A of latest NTDC type test policy
5. Resistance test of complete conductor 6. Tensile test of complete conductor	i. Any Independent Lab accredited by ISO/IEC 17025 ii. Any lab as per Annexure-A of latest NTDC type test policy iii. Inspection reports issued by any STL Lab
HARDWARE & ACCESSORIES	
1. Corona /RIV Test 2. Power arc test 3. Heat cycle test 4. Magnetic loss test	Any lab as per Annexure-A of latest NTDC type test policy
5. Resistance test 6. Galvanization test 7. Resistance to conductor slippage test 8. Mechanical tests	i. Any Independent Lab accredited by ISO/IEC 17025 ii. Any lab as per Annexure-A of latest NTDC type test policy iii. Inspection reports issued by any STL Lab
SB-DAMPERS	
1. Corona and RIV 2. Damper Performance 3. Vertical Fatigue (Damper Fatigue Test)	Any lab as per Annexure-A of latest NTDC type test policy
4. Galvanization 5. Clamp Slippage Test at Ambient Temp. 6. Bolt Torque 7. Attachment of Weights to Messenger Cable 8. Attachment of Clamp to Messenger Cable	i. Any Independent Lab accredited by ISO/IEC 17025 ii. Any lab as per Annexure-A of latest NTDC type test policy iii. Inspection reports issued by any STL Lab
INSULATORS (80kN,100kN & 120kN)	
1. Low-Frequency Dry Flashover Test 2. Low-Frequency Wet Flashover Test 3. Critical Impulse Flash over Test 4. Radio Influence Voltage T 5. Thermal Mechanical Load Cycle Test 6. Steep Wave Front 7. Power Arc Test 8. Artificial Pollution Performance Test 9. Cement Expansion	Any lab as per Annexure-A of latest NTDC type test policy

10. Galvanization 11. Cotter Key Test 12. Thermal Shock Test 13. Residual-Strength Test 14. Impact Test	i. Any Independent Lab accredited by ISO/IEC 17025 ii. Any lab as per Annexure-A of latest NTDC type test policy iii. Inspection reports issued by any STL Lab

22.15 PACKAGING AND SHIPPING

The packaging should be made in a way to fully protect the coating at the surface of insulators during transit to their final destination or storage and subsequent installation at site. Packing case size and weight shall be taken into consideration, their appropriate, the remoteness of the final destination or the goods and the absence of heavy handling facilities at all points in transit.

22.16 PERFORMANCE GUARANTEE

A ten (10) years guarantee starting from the date of final taking over certificate shall be given by the contractor for the RTV coating of insulator confirming that no flash over & no arcing will occur on the coated insulators within ten years guarantee period. Such guarantee letter shall be attached with offer. In case of observance of crack / pill off of the coating within guarantee period, the same shall be attended free of cost.

23. SPECIFICATION FOR TOWERS

23.1 Fabrication of Steel Structures (P-139: 80) &T.P
(Including Amendment No. 1, dated 3rd October 1982)

23.2 Zinc Coatings (P-82: 81) &T.P

23.3 Barbed Wire (Including Amendment No.1 dated 5th Jan.1989) (P-162:81)

23.4 Number, Danger and Sign Plates
(Including Amendment No.1, dated 12th December 1981) (P-104:76)

23.5 Plain Steel Washers (P-20:68) &T.P

23.6 Painting of steel towers Technical Provision

24. SPECIFICATIONS FOR STEEL POLES

24.1 Galvanized Steel Pole (P-166-83) &T.P
24.2 Zinc Coatings (P-82:81) &T.P
24.3 Wind Load IEC 60826(CAT: D)
24.4 Material ASTM-572 Gr 65 & ASTM-394
24.5 Painting of steel poles Technical Provision

25. SPECIFICATIONS FOR CONDUCTOR AND ALUMOWELD SHIELD WIRE

25.1 Aluminium Alloy Stranded Conductor (P-117: 88) & T.P
(Including Amendment No. 1, dated 12th February 1990)

25.2 Alumoweld Shield Wire ASTM B-416 & T.P
25.3 Wind Load on Conductor IEC 60826(CAT: D)

26. SPECIFICATIONS FOR INSULATORS AND HARDWARE

26.1	Disc Type Porcelain Insulators	(P-008: 96) & T.P
26.2	Suspension Strings for Single Conductor	(P-140: 82) & T.P
26.3	Tension Strings for Single Conductor	(P-143: 82) & T.P
26.4	Zinc Coating	(P-082: 08) & T.P
26.5	Wind Load on Insulator String	IEC 60826(CAT: D)

27. SPECIFICATIONS OF HARDWARE FOR ALUMOWELD SHIELD WIRE

27.1	Suspension Fitting for Alumoweld Shield Wire	P-141&T.P
27.2	Tension Fitting for Alumoweld Shield Wire	P-141&T.P

28. SPECIFICATIONS FOR CONDUCTOR AND ALUMOWELD SHIELD WIRE ACCESSORIES AND DAMPERS

28.1	Mid Span Joints and Repair Sleeves for T/Lines i. (Including Amendment No. 1, dated December 1982)	(P-144: 80) & T.P
28.2	Mid Span Joints (AWS)	(P- 141) & T.P
28.3	Stock Bridge Vibration Damper ii. (Including Amendment No. 1, dated 25th November 1990)	(P-142:83) & T.P
28.4	Stock Bridge Vibration Damper (AWS)	(P-142:83) & T.P

29. SPECIFICATIONS FOR GROUNDING MATERIAL

29.1.	Earth Rod	(P-116:81)
29.2.	Copper wire for earthing	(P-16:68)

30. APPLICABLE AMENDMENTS FOR TECHNICAL PROVISIONS

30.1. FABRICATION OF STEEL STRUCTURES (P-139:80)

Please replace clause 8.3 with the following:

<u>Check Assembly of Towers</u>

Before proceeding with the bulk fabrication of any type of tower, the Contractor shall fabricate and assemble in his works for inspection by the purchaser or his authorized representative, one tower of each type as finally approved by the purchaser for checking the fabrication accuracy and workmanship. The check assembly shall be preferably in vertical position. In case of assembly in horizontal position, the complete tower assembled along with body/leg extensions shall be adequately supported to prevent distortion and overstressing of members to ensure proper fit and shall be accomplished without extraordinary effort to align bolt holes or to force pieces into position. For the check assembly, bolts and nuts shall be not more than finger tight. The members and nuts, bolts, lock nuts, washers, fillers etc. used in prototype assembly shall be of the same grade & size/dimensions specified in the approved drawings and to be supplied against the respective contract/purchase order.

30.2. ALUMINUM ALLOY STRANDED CONDUCTOR (P-117:88)

i. Add following clause before <u>clause 6</u> in the specification:

6a) **Tests**

6a.1) **Type tests**

The following type tests shall be carried out in accordance with clauses and standards mentioned against each

1.	Stress strain test	IEC 61089 (Annex B)
1a.	Stress strain curves	As detailed below
2.	Creep test	IEC 61395
3.	Tensile test on composite conductor	IEC 61089
4.	Joints in Aluminum wires	IEC 61089

Stress strain curves

The supplier shall provide the data with initial and final stress-strain curves for the conductor. These stress-strain curves shall be obtained using the "Standard Method of Stress-Strain Testing of Aluminum Conductor and ACSR" prepared by "The Aluminum Association", 420 Lexington Avenue, New York N.Y.10017, USA.

The creep curves shall be shown for the conductor held at a constant tension of 15%, 20%, 25% and 30% of the rated ultimate tensile strength of the conductor. These shall be presented on log-log paper, with a minimum of 5 cycles on the time scale. These data shall be based on tests carried out for a minimum of 1000 hours to obtain the degree of accuracy required.

ii. Add following clause before clause 6 in the specification

6a.2) Sample tests

The following sample tests shall be performed on the offered type of conductor in accordance with WAPDA specification P-117:88, supplemented by applicable IEC, ASTM Standards.

1.	Visual examination	As detailed at ‘a’
2.	Verification of dimensions	As detailed at ‘b’
3.	Measurement of lay ratio of each layer	As detailed at ‘c’
4.	Tensile test on whole conductor	As detailed in specification
5.	Breaking load of individual wires	As detailed in specification
6.	Wrapping test	As detailed in specification
7.	Resistivity test on aluminum wires	As detailed in specification
8.	Bend test	As detailed at ‘d’

Sample test # 1, 2, 3 & 8 shall be performed as described below and supplemented by applicable IEC & ASTM standards.

a. Visual Examination

The conductor shall be examined visually for good workmanship and general surface finish and shall generally conform to the requirements of the specification. The conductor will be initially checked for any scratches, joints, burrs, indentation, black and bare spots, projections, slackness, spacing between the individual wires, bird caging etc. The offered Lot will be rejected if any of the above mentioned defects persist in the length of the conductor.

The conductor reels shall be visually and dimensionally checked to ensure that they confirm to the requirements of this specification. The reels shall be of sound construction and properly seasoned. Wet or termite effected reels will be rejected. Thick paper board shall be applied inside the flange and polypropylene sheets shall be applied on the drum of the wooden reels before winding of the conductor on the reels to avoid damage to the conductor. Polyethylene sheets shall be wrapped over the conductor after winding. The reels without these accessories will be rejected.

The conductor will be wound on reels in a way so as to avoid scratching during re-winding of conductor; as such scratching persistently existing will result in rejection of conductor on that reel.

b. Verification of Dimensions

The diameters of individual aluminum wires, diameter of complete conductor, unit weight of conductor etc., shall be checked by selecting 10% of the material of a given lot.

To check the weight and complete length of conductor (as specified in the specifications) on a certain reel, 5% of the reels shall be selected from the offered lot. The reels with conductor shall first be checked for weight, the conductor shall be completely rewound from the reel and the weight of the empty reel will be taken again to check the total weight of the conductor on the reel.

All the results shall confirm to the values specified in the specifications and any variations will only be allowed as per the tolerances specified, beyond which, the material will be rejected.

c. Measurement of Lay-Ratio of Each Layer

The lay-ratios of each layer of the conductor shall be measured and checked to ensure that they conform to the requirements specified in clause 5.4 and table-II of this specification.

d. Bend Test

For bending properties, five percent (5%) of the reels shall be checked. The bending properties shall be ensured by rewinding of the conductor. The samples selected under clause b (verification of dimensions) may be used for this test also.

During rewinding, the conductor shall be checked for any kinks, stresses, broken strands and the defects mentioned in clause a (Visual Examination). The presence of any of the aforementioned defects will result in the rejection of the whole lot offered for inspection.

iii. Add the following paragraph at the end of clause 5.5.4:

Strength of Conductor

Before starting the test, circles perpendicular to the axis of the conductor shall be marked at two places on the sample of conductor. The load shall be increased at a steady rate up to 50% of minimum specified UTS and held for one minute. The circles drawn shall not be distorted due to relative movement of strands. Thereafter the load shall be increased at steady rate to 95% of UTS and held for one minute. The Conductor sample shall not fail during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

30.3. SUSPENSION STRINGS (P-140:82)

a) Add the following at the end of Clause 7.1.

iv. Power Arc Test } For complete insulator string
v. Magnetic Losses Test }

b) Add the following at the end of Clause 10.

Power Arc Test

The power arc test shall be performed in accordance with IEC 61467 for test series "X" on complete hardware assembly including insulators.

Magnetic Losses Test

The test shall be performed as per IEC 61284 on conductor suspension clamp to ascertain the magnetic losses.

30.4. TENSION STRINGS (P-143:82)

a) Add the following at the end of Clause 7.1.

vi. Power Arc Test For complete insulator string

b) Add the following at the end of Clause 14.

Power Arc Test

The power arc test shall be performed in accordance with IEC 61467 for test series "X" on complete hardware assembly including insulators and compression dead end splices.

30.5. STOCK BRIDGE VIBRATION DAMPERS (P-142: 83)

i. Clause 2, Table I

Add the following at the end of the table:

"h) Stock Bridge Dampers for "AASC GREELEY, SB-G, 28.14mm"

ii. Clause 3.1

Add the following paragraph at the end:

"The Stockbridge vibration dampers shall be of 4-R (four resonance) design. The supplier shall provide the frequency range of the offered dampers along with dynamic response curves.

The dynamic strain caused by vibration in the vertical direction shall not exceed 200 µm/m peak-to-peak at the suspension point as measured by the recommended method of the IEEE Aeolian Vibration Task Force (IEEE Paper No 31 TP 65-156) (PES-TR17) for AASC conductor and as well as 200 µm/m peak-to-peak alumoweld shield wire (AWS). Vibration level in terms of $f \cdot y_{max}$ shall not exceed 40 mm/s 0-peak. Bending amplitude when measured in accordance with IEEE Std. 1368 "IEEE Guide for Aeolian Vibration Field Measurements of Overhead Conductors" shall not exceed 0.23 mm (9 mils) 0-peak for AASC conductor.

iii. Clause 3.2, Table-II

a) Add the following at the end of Table-II

(1):

Name of Conductor	**Overall Diameter (mm)**	**Unit Weight (kg/km)**	**Rated UTS (Kg)**	**E.D. Stress(%) at 25°C**	**Average Span Length (m)**	**Vibration Frequency Range (Hz)**	**No. of Dampers Per Span**
AASC Greeley	28.14	1289	13835	12	200	4-100	2
				14	240		
				18	340		
				22	340		

(2):

Name of Wire	**Overall Diameter (mm)**	**Unit Weight (kg/km)**	**Rated UTS (kg)**	**E.D. Stress(%) at 25°C**	**Average Span Length (m)**	**Vibration Frequency Range (Hz)**	**No. of Dampers Per Span**
Alumoweld Shield Wire	9.78	390	7226	10	200	10-165	2
				12	240		
				15	340		

b) 2 dampers per span of AASC Greeley conductor as well as of alumoweld shield wire (AWS) should be designed installing one damper on each end of the span for average span length given against every day stress. Contractor shall ascertain the dampers spacing and the number required in accordance with the sag-tension, span lengths and environmental conditions of the site.

c) Delete the note given at the end of the table.

d) A drawing showing dampers location for various span lengths along with its distance of installation shall be submitted with the bid.

iv. Clause 4.1

a) Add the following text at the end of this clause:

"The clamping area shall be such that damper neither slips nor damage the conductor/overhead shield wire. When installed at the recommended torque, the clamp shall not slip below 250kg force for conductor respectively. The clamps of vibration dampers shall be able to withstand a bolt torque equal to 150 percent of nominal design installation torque."

v. Clause 4.2

a) Add the following sentence at the end of the clause: "Break away bolts shall be required for dampers".

vi. Add the following new clauses 5.1.4 to 5.1.8 after clause 5.1.3:

5.1.4 The following tests shall be performed on each of at <u>least two assemblies</u> selected at random and performed in the order prescribed below.

5.1.5 <u>Clamp Slippage Test at Ambient Temperature</u>

The test shall be carried out on a length of specific conductor/shield wire tensioned at E.D. Stress given in table-II. The vibration damper shall be installed on the conductor in accordance with manufacturer installation instructions by applying a tightening torque on the upper head of break-away bolt until breakage of the upper head occurs. The relevant torque shall be recorded. Then a load of 250kg for conductor shall be applied to the clamp parallel to the axis of conductor/shield wire and held for minimum 1 minute without initial slip. The initial slip load is defined as the load at which the clamp moves 0.5mm or more on the conductor. The load shall be increased until the continual slip occurs. The relevant value shall be recorded.

5.1.6 Bolt Torque Test

The test shall be carried out on the samples submitted to above test. After completion of the above test, a torque of 150 percent of nominal design installation torque shall be applied at lower head of the bolt in order to see that there shall be no failure of component parts. Records shall be made of the lower head withstand torque, failure torque and the part(s) of the clamp assemblies that fail.

5.1.7 Corona Test

The corona extinction voltage for the stock bridge vibration dampers shall be determined visually in a virtually dark laboratory. The corona extinction voltage is the voltage at which the damper is free of all visual corona.

The vibration dampers type SB-G shall be installed on section of AASC "Greeley" conductor or bar of equivalent diameter. The conductor or bar shall be arranged in the configuration similar to be used in the field.

The vibrations dampers shall be subjected to a voltage determine that the corona extinction voltage level is not less than 100kV line to ground for 132kV nominal voltage. The ground plane shall be a maximum of 4 meters from the assembly.

The exposure shall be made with an applied voltage and the laboratory virtually dark. There shall be no evidence of corona on the Vibration Dampers.

5.1.8 The RIV test shall be performed in accordance with IEC 60437 and IEC 6128.

vii. Clause 5.2, Sample Test

a) Add the following at the end of this clause:

iv. Clamp slippage Test at Ambient Temperature
v. Bolt Torque Test
vi. Attachments of Weights to Messenger Cable
vii. Attachments of Clamp to Messenger Cable
viii. Damper Characteristic Test
ix. Damper Fatigue Test

viii. Clause 6, TEST METHODS

a. Read title of this clause as “TEST METHODS FOR SAMPLE TESTS” instead of “TEST METHODS”.

ix. Add the following new clauses 6.4, 6.5, 6.6, 6.7, 6.8 and 6.9 after clause 6.3:

6.4 Clamp Slippage Test at Ambient Temperature

As given in clause 5.1.5.

6.5 Bolt Torque Test

As given in clause 5.1.6.

6.6 Attachments of weights to messenger cable

This test shall be performed in accordance with Clause 7.8 of IEC 61897 and should conform to the acceptance criteria stated therein.

6.7 Attachment of Clamp to Messenger Cable Test

This test shall be performed in accordance with Clause 7.9 of IEC 61897 and should conform to the acceptance criteria stated therein.

6.8 Damper Characteristic Test

This test shall be performed in accordance with Clause 7.11.2 of IEC 61897.The results thus obtained should fulfill the respective acceptance criteria.

The damper dynamic stiffness shall fulfill the following ‘OPTIMUM DAMPER’ criterion:

The frequency range of the damper, according to IEC 61897, Clause 7.11.2, must be between f_1 and f_2, being $f_1 = 0.18/d$ and $f_2 = 1.4/d$ – where d is the conductor diameter in meters.

Between f_1 and f_2, the following conditions must be fulfilled:

$0.5\ F_{opt} < F/u < 2.5\ F_{opt}$
$20\ deg < \varphi < 160 deg$

where F/u is the force transmitted by the damper per unit displacement of the damper clamp and φ is the phase between force and displacement.

F_{opt} is the damper optimum force, defined as:

$$F_{opt} = 4\pi f\sqrt{Tm}$$

where T is the cable tensile load [N] at everyday conditions (EDS), m is the cable mass per unit length [kg/m] and f is the vibration frequency [Hz].

6.9 Damper Fatigue Test

Damper Fatigue Test shall be carried out on each sample which have first been subjected to damper characteristics test. The test shall be performed in accordance with international standard specification IEC 61897. The results thus obtained should fulfill the acceptance criteria stated there in damper characteristic test shall be performed in accordance with clause 7.11.2 the result obtained should fulfill the factor criteria status caring.

x. TABLE-III, Page-5

a) Line 3 of the title of middle column may be read as “in Clause 6.3,6.4, 6.5, 6.6, 6.7 & 6.8” instead of existing “in Clause 6.3”.

ANNEXURE-A

132kV Tubular Steel Pole Type "SPT-C"

Summary of Critical Calculation Results of Each Section of Pole and Xarms

Annexure A:

Case #	Sections		Dead Loads(kN)		Shear Loads(kN)		Bending Moments(KN-m)		Ultimate Load(kN)			Calculated Stresses(MPa)			Combined Calculated Stresses (MPa)	Allowable Stresses (MPa)	Max Usage(%)	Theoretical Weight(kN)
			Pole	Cond	Pole	Cond	Pole	Cond	Axial	Bending	Shear	Axial	Bending	Shear				
	Upper Xarm	Trans																
		Long																
	Middle Xarm	Trans																
		Long																
	Bottom Xarm	Trans																
		Long																
	Sec# 1	Trans																
		Long																
	Sec#2	Trans																
		Long																
	Sec#3	Trans																
		Long																

132kV Tubular Steel Pole Type   "SPM-C"

Summary of Critical Calculation Results of Each Section of Pole and Xarms

Annexure A:

Case #	Sections		Dead Loads(kN)		Shear Loads(kN)		Bending Moments(KN-m)		Ultimate Load(kN)			Calculated Stresses(MPa)			Combined Calculated Stresses (MPa)	Allowable Stresses (MPa)	Max Usage(%)	Theoretical Weight(kN)
			Pole	Cond	Pole	Cond	Pole	Cond	Axial	Bending	Shear	Axial	Bending	Shear				
	Upper Xarm	Trans																
		Long																
	Middle Xarm	Trans																
		Long																
	Bottom Xarm	Trans																
		Long																
	Sec# 1	Trans																
		Long																
	Sec#2	Trans																
		Long																
	Sec#3	Trans																
		Long																

132kV Tubular Steel Pole Type "SPH-C"

Summary of Critical Calculation Results of Each Section of Pole and Xarms

Annexure A:

Case #	Sections		Dead Loads(kN)		Shear Loads(kN)		Bending Moments(KN-m)		Ultimate Load(kN)			Calculated Stresses(MPa)			Combined Calculated Stresses (MPa)	Allowable Stresses (MPa)	Max Usage(%)	Theoretical Weight(kN)
			Pole	Cond	Pole	Cond	Pole	Cond	Axial	Bending	Shear	Axial	Bending	Shear				
	Upper Xarm	Trans																
		Long																
	Middle Xarm	Trans																
		Long																
	Bottom Xarm	Trans																
		Long																
	Sec# 1	Trans																
		Long																
	Sec#2	Trans																
		Long																
	Sec#3	Trans																
		Long																

ANNEXURE-B

132kV Tubular Steel Pole Type

Foundation Reaction Loads at Concrete Level

Annexure B:

Pole Type	A/Bolt Circle (mm)	A/Bolt(#) L'th x Q'ty (mm x ea)	Loading Condition	Axial Force (tons) Fx	Shear Force(tons)		Torsion Moment Mx	Bending Moment(ton-m)		Remarks
					Transverse Direction Fy	Longitudinal Direction Fz		Transverse Direction Mz	Longitudinal Direction My	
SPT-C			Case#							
			Case#							
SPM-C			Case#							
			Case#							
SPH-C			Case#							
			Case#							
			Case#							

ANNEXURE-C

GEOTECHNICAL INVESTIGATIONS FOR CONSULTANCY SERVICES FOR 132KV TRANSMISSION LINE AND GRID STATIONS INCLUDING DESIGN, CONSTRUCTION, SUPERVISION AND ALLIED ACTIVITIES AND TESTING & COMMISSIONING FOR INTERCONNECTION OF ISOLATED MAKRAN AREA WITH NATIONAL GRID WORK

1. INTRODUCTION

The Client "Quetta Electric Supply Company (QESCO)" has planned to install "Six (06) 132KV TRANSMISSION LINES from GAWADAR to Naal". M/S Enmasse Pvt Ltd has awarded the project by the client to construct these transmission lines as a consultant.

For the safe and reliable design of the structure, geotechnical investigations were considered mandatory to explore the subsurface for foundation design. M/S Enmasse Pvt Ltd has entrusted the M/S Pioneer Associates to undertake Geotechnical Investigations for foundation design of towers for transmission lines.

The design of four boreholes (BH-16, BH-17, BH-18 & BH-19) is provided seperatly in this report on the demand of consultant of the project. These boreholes are part of "132 kV Gwadar – Turbat T/Line". This report presents the factual data comprising the borehole logs and laboratory test results, discussion on the subsurface conditions and foundation design recommendations in the light of field exploration and laboratory testing.

1.1 Objectives of soil investigations

For reliable and safe foundation design, geotechnical investigations, which include site exploration and laboratory testing on soil samples, were required. The investigations were aimed at obtaining information about subsoil conditions of the project area, in general, to design safe foundations of the project. The main objectives are as follows:

1. To investigate the properties of different subsoil strata along the proposed transmission line route by exploratory boreholes.
2. To obtain the truly representative geotechnical parameters by field and laboratory testing of soil and ground water (if encountered) samples.
3. To calculate the allowable bearing capacity for shallow foundations and allowable pile capacity for deep / pile foundations.
4. To provide the recommendations regarding the type and construction of foundations, excavations for the foundations, type of cement required, seismic hazards (if any).

1.2 Scope of work

Following is the scope of work for the present geotechnical investigations:

1.2.1 Field Investigations

- Drilling of total four (04) boreholes up to maximum of 25m depth.
- Performance of Standard Penetration Test (SPT) at 1m interval in soil.
- Collection of disturbed soil sample (DS).
- Collection of Undisturbed soil samples (UDS).
- Collection of water Samples (WS).
- Packing, labeling and transporting the soil and water samples to the testing laboratory as per the laboratory testing plan (LTP) approved by the consultant.

1.2.2 Laboratory testing

Following laboratory tests conducted by SOILCON (soil samples) & PCSIR (water samples) as per the standards mentioned.

- Grain Size analysis (Sieve & Hydrometer) (ASTM D- 422)
- Atterberg Limits (ASTM D- 4318)
- Natural Moisture Content (ASTM D- 2216)
- Bulk & Dry Densities (ASTM D- 4531)
- Specific Gravity Test (ASTM D- 854)
- Unconfined Compression Test (Soil) (ASTM D- 2166)
- Direct Shear Test (ASTM D- 3080)
- Chemical Analysis of water samples

1.2.3 Reporting of field and laboratory data

Compilation of geotechnical investigation report including borehole log and laboratory test results together with the foundation design recommendations.

2. FIELD INVESTIGATIONS

Field investigations included drilling of borehole by Straight Rotary with performance of SPTs at given intervals, logging of boreholes, collection of soil and water samples also performing of in-situ tests.

2.1 Borehole drilling

Drilling of boreholes was the major part of present investigations, through which subsoil conditions were explored, in-situ testing was carried out and samples were collected for further testing in the laboratory. Location and depth of boreholes are shown below.

Location/ Transmission Lines	Borehole No.	Depth (m)	Coordinates		Depth of Ground Water below NSL (m)
			Easting	Northing	
132 kV Gwadar – Turbat T/Line	BH-16	25	458088.00	2795853.00	1.0
	BH-17	20	457831.00	2796716.00	0.8
	BH-18	20	460940.00	2799334.00	1.0
	BH-19	20	464575.00	2800943.00	1.0

2.2 Standard Penetration Test (SPT)

The objective of this test is to ascertain the resistance afforded to the penetration apparatus in order to obtain an estimate of the in-situ properties. This test gives valuable information regarding the compactness of the soil. In the field, SPT was performed in accordance with ASTM D-1586.The N-value of the soil column was recorded and mentioned on filed logs.

2.3 Field Logs

Preparation of log is a continuous process in the field. A competent geological engineer/geologist has prepared the borehole log. The log is prepared carefully in the light of encountered subsurface material in the borehole. The field log was finalized in the light of laboratory test results. The borehole log is attached as Appendix B.

2.4 Sampling

Geotechnical investigation for any project cannot be completed without collecting good quality soil and water samples from subsurface strata. A number of samples were collected during present investigations.

2.4.1 Undisturbed soil Samples

From all boreholes, total three(03) UDS had taken in the soil by Shellby tubes as per the suitability. The samples were waxed and properly preserved with labels and subsequently transported to the laboratory for further testing as per the lab testing plans.

2.4.2 Small Disturbed Samples

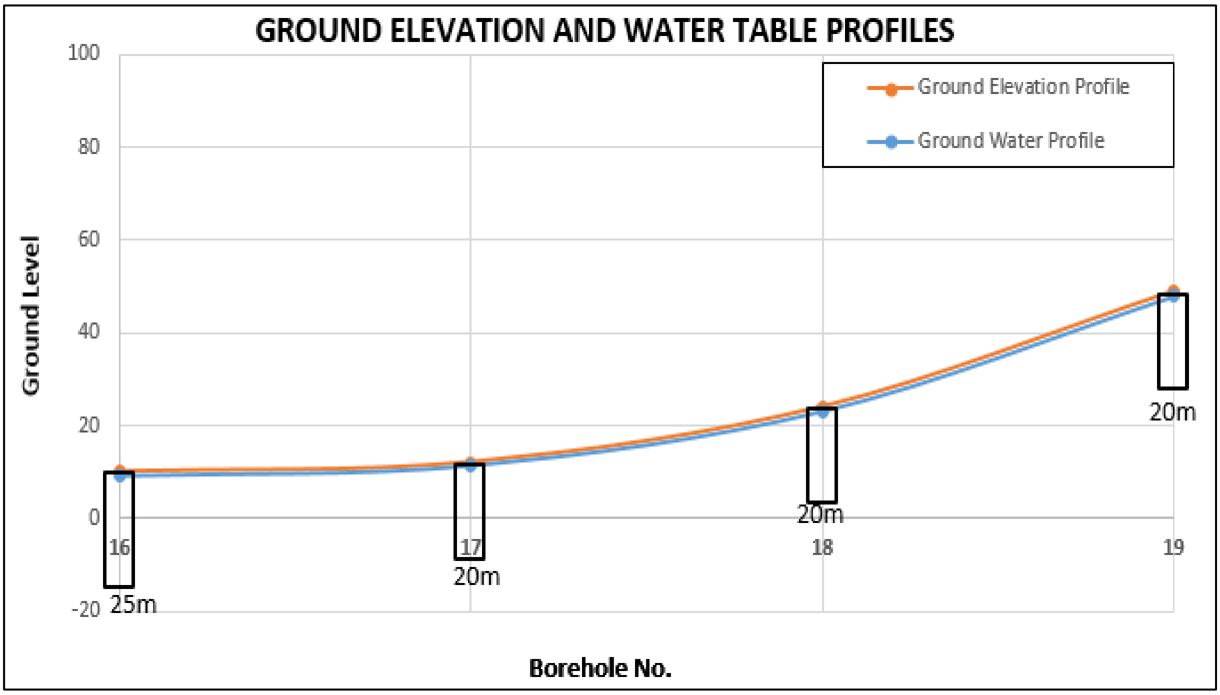
From all borehole containing overburden, small disturbed samples were collected through SPT split spoon sampler. All the disturbed soil samples were shifted to the laboratory for necessary testing as per the lab testing plans.

2.4.3 Water Samples

Water table is encountered in all five boreholes at about 0.8m – 1.0m depth from NSL. The water samples are collected from the boreholes for their chemical analysis.

2.5 Ground Elevation and Ground Water Table Profiles

The Change in the elevation along the Transmission Line and fluctuation of ground water table are discussed in the next subsections and showed in the graphical form in the figure below.



2.5.1 Ground Elevation

The Transmission Line Stretch of these four boreholes is mostly in the plain area having elevation from 10m – 49m.

2.5.2 Ground Water Table

The Ground Water table has encountered in all boreholes during the field investigations, The maximum explored depth during these field investigations is 25m below NSL in case of BH-16.

3. LABORATORY TESTING

The laboratory testing was conducted on undisturbed and disturbed soil samples for classification of soil and determination of strength characteristics. The tests are discussed in the following sections and summarized in table under the title "Summary of Laboratory Test Results". Laboratory test data sheets are attached as Appendix B.\

3.1 Classification Tests

Grain size analysis, Atterberg limits and Natural moisture content tests were carried out for establishing the classification of various foundation soils. These classification tests are discussed hereunder.

3.1.1 Sieve analysis

Fourteen (14) soil samples were analyzed for grain size determination. The results have been presented as “Grain Size Analyses” curves and have been included in Appendix C. The summary of these results is presented in table under the title “Summary of Laboratory Test Results”.

3.1.2 Atterberg’s limits

Ten (10) soil samples from all the boreholes were tested for the determination of Atterberg’s limits. The results are summarized in table under the title “Summary of Laboratory Test Results” and test data sheets are attached as Appendix C.

3.2 Specific Gravity

The Pycnometer is used for determination of specific gravity of soil particles of both fine grained and coarse-grained soils. The determination of specific gravity of soil will help in the calculation of void ratio, degree of saturation and other different soil properties. Two (02) samples are tested for the specific gravity analysis. The results are summarized in table under the title “Summary of Laboratory Test Results”.

3.3 Strength tests

For determination of strength parameters of subsurface soil i.e. Cohesion and Angle of internal friction, following strength test was to be conducted on undisturbed soil samples. Since the soil at the project site was mainly the cohesive in nature so unconfined compression strength tests were considered more appropriate. The results are summarized in table under title “Summary of Laboratory Test Results” and test data sheets are attached as Appendix C.

3.3.1 Unconfined compression tests

The unconfined compressive strength is the compressive strength at failure of a soil specimen subjected to unconfined compressive load. It provides a direct quantitative measure of consistency of cohesive soils. The information furnished by unconfined compression test was used in determining the shearing strength of the soils. For cohesive soils, shearing strength is equal to half the compressive strength.

One (01) **soil samples** of cohesive soil were tested for unconfined compression in accordance with ASTM D-2166. The test results of the tested sample are summarized in table under title “Summary of Laboratory Test Results “and data sheet is attached as

Appendix C.

3.3.2 Direct Shear Test

For the soils possessing non-cohesive characteristics, direct shear tests were done on one (01) selective samples in saturated condition as per ASTM D- 3080 to find out the angle of internal friction of the sandy soils.

3.4 Bulk Density and Natural Moisture Content Determination

Selective one (01) samples were used for the determination of bulk densities of soil and two (02) samples for natural moisture content. The results are summarized in table under the title “Summary of Laboratory Test Results”.

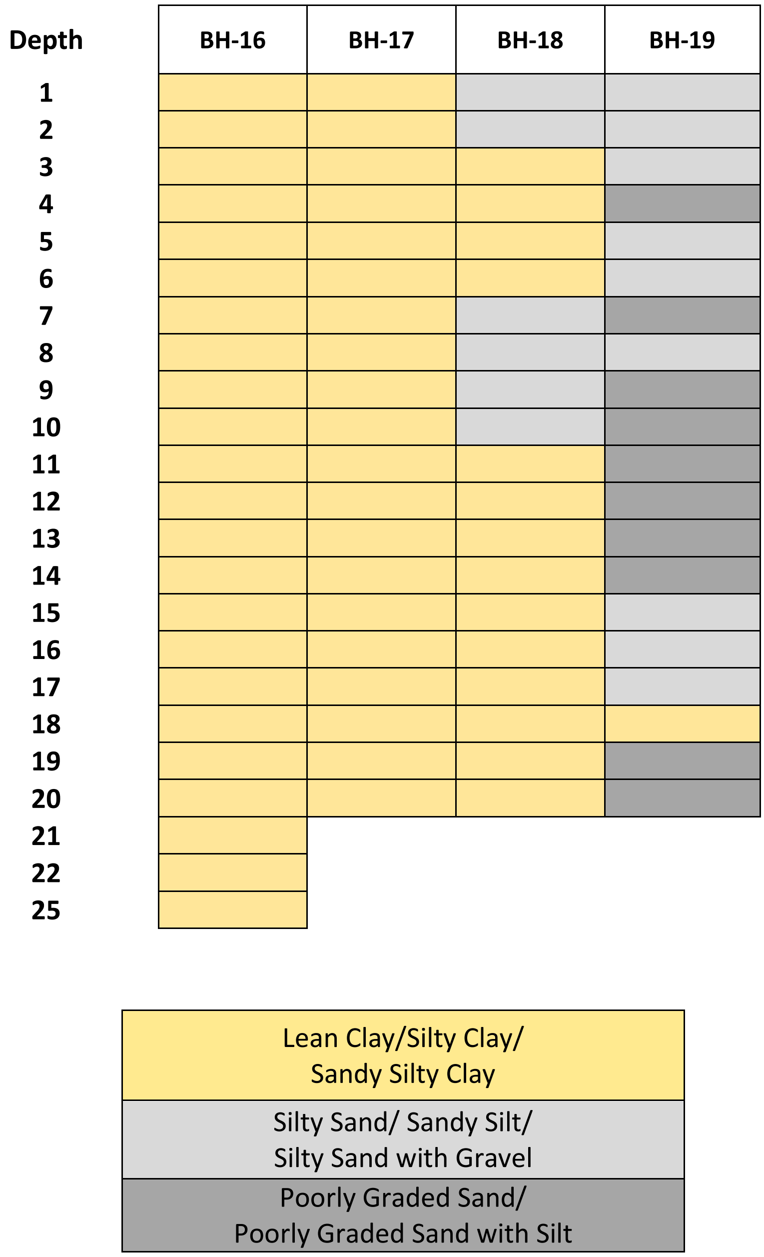
3.5 Chemical Test on Water Samples

Water Samples are tested to find Chloride content, Sulphate content, TDS and pH. These tests are carried on the selective two (02) samples as ground water table was encountered in just three boreholes. The results are summarized in table under the title “Summary of Laboratory Test Results”.

4. SITE GEOTECHNICS

4.1 Lithology and stratigraphy

The strata encountered in BH-16, BH-17 & BH-18 was mostly same in nature (cohesive) boreholes was varies and consists of cohesive, non-cohesive soils, gravels and rock (Silt stone & Sand stone). Detailed description of the soil units can be found in borehole logs attached as Appendix B. The soil profile of each borehole obtained by exploration comprises of the following lithological units:



4.2 Geotechnical Models

All the boreholes are categorized in single generailized Geotechnical Model on the basis of:

- SPT-N Values and other characteristics obtained from field testing of top 5m – 6m. strata, three Geotechnical models are shown as follows:

Depth (m)	Geotechnical Model
1	Lean/Silty Clay (Firm to Stiff)
2	
3	Lean Clay/ Silty Clay, Silty Sand (Stiff to Very Stiff)
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	Lean Clay/ Silty Clay (Very Stiff to Hard)
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
25	

SUMMARY OF LABORATORY TEST RESULTS

CONSULTANCY SERVICES FOR 132KV TRANSMISSION LINE AND GRID STATIONS INCLUDING DESIGN, CONSTRUCTION, SUPERVISION AND ALLIED ACTIVITIES AND TESTING & COMMISSIONING FOR INTERCONNECTION OF ISOLATED MAKRAN AREA WITH NATIONAL GRID WORK

Bore hole No.	Depth	Grain Size Analysis			NMC	Liquid & Plastic Limit			Classification (USCS)	Density		Specific Gravity	Point Load Strength	Direct Shear Test		Unconfined Compression Test		Consolidation Test Cv
	m	Gravel (%)	Sand (%)	Silt & Clay (%)	%	L.L	P.L	P.I		Bulk (g/cm³)	Dry (g/cm³)	Gs	Is(50) MPa	Angle of Friction (ϕ)	Cohesion (MPa)	q_u (kPa)	Strain (%)	cm³/sec
BH-16	3.0 UDS	–	6	94	16.9	21	15	6	Silty Clay	1.884	1.617	–		–	–	6.867	3.79	–
	5.0	–	5	95	–	22	16	6	Silty Clay		–	–		–	–	–	–	–
	10.0	–	3	97	–	22	16	6	Silty Clay		–	–		–	–	–	–	–
	16.0	–	7	93	–	22	16	6	Silty Clay		–	–		–	–	–	–	–
BH-17	4.0 UDS	–	7	93	9.2	24	17	7	Silty Clay		–	–		–	–	–	–	–
	5.0	–	10	90	–	24	16	8	Lean Clay		–	2.76		–	–	–	–	–
	9.0	–	8	92	–	28	19	9	Lean Clay		–	–		–	–	–	–	–
BH-18	1.0	–	27	73	–	–	–	–	Silt with Sand		– –	–		–	–	–	–	–
	5.0 UDS	–	4	96	–	21	15	6	Silty Clay		– –	–		–	–	–	–	–
	11.0	–	4	96	–	30	20	10	Lean Clay		– –	–		–	–	–	–	–
BH-19	2.0	9	39	52	–	NON-PLASTIC			Sandy Silt	–	–	–		35.0	0	–	–	–
	3.0	–	71	29	–	–		–		–	–	2.71		–	–	–	–	–
	4.0	–	67	33	–	–		–	Silty Sand	–	–	–		–	–	–	–	–
	15.0	10	28	62	–	–		–	Silt with Sand	–	–	–		–	–	–	–	–
	5.0	8	30	62	–	21	15	6	Sandy Silty Clay	–	–	–		–	–	–	–	
	4.0	89	4	7	–	–		–	Poorly Graded Gravel	–	–	–		–	–	–	–	

BOREHOLE LOG

pioneer associates

BOREHOLE NO.	BH-16
ELEVATION:	10 m
N:	2795853.00 m
E:	458088.00 m

PROJECT: CONSULTANCY SERVICES FOR 132 KV TRANSMISSION LINE AND GRID STATIONS INCLUDING DESIGN, CONSTRUCTION, SUPERVISION AND ALLIED ACTIVITIES AND TESTING & COMMISSIONING FOR INTERCONNECTION OF ISOLATED MAKRAN AREA WITH NATIONAL

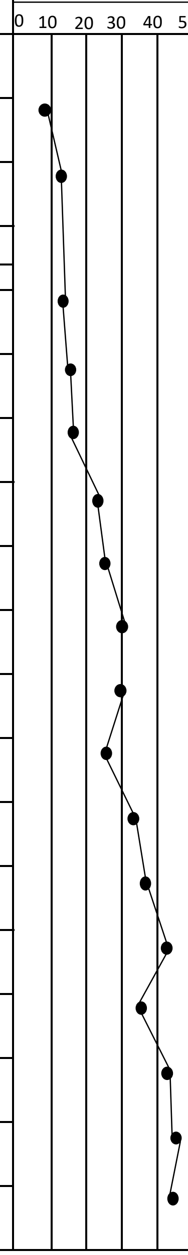
LOCATION: Gwadar to Turbat

JOB NO:	CLIENT:	CONSULTANT:	DATE STARTED	DATE COMPLETED
PA / GI / 20 / 927	QESCO	M/S ENMASSE PVT LTD	5/3/2020	5/3/2020

DRILLING INFORMATION			GROUND WATER			
DRILLING METHOD / EQUIPMENT: Straight Rotary			DATE	TIME	WATER DEPTH (m)	CASING DEPTH
DRILLING DEPTH: 25 m	DIA OF DRILLING: 4 inches		6/3/2020	---	1.0	---
CORE BARREL: NX- Double Tube	BIT: Fish Bit - Tungsten Carbide		DRILLER: M ZOHAIB			
SAMPLER: S.P.T / C.P.T	Wt. of SPT Sampler : 63.5kg	DROP: 75 cm	SITE GEOLOGIST: ABDUL WAHID		CHECKED BY: SALMAN AYUB	

DEPTH (m)	SOIL GROUP	SUBSURFACE DESCRIPTION	SAMPLE LENGTH (cm)	SPT BLOWS PENETRATION 6"	6"	6"	SPT N-VALUE	REMARKS
0–1	CL-ML	SILTY CLAY Greyish brown, stiff, low plastic, moist.						
1			32	4	4	5	9	SPT-01
2			30	5	4	7	11	SPT-02
3		SILTY CLAY Greyish brown, stiff, medium to low plastic, wet	34	SHELLBY TUBE				UDS-01 @ 3.0m
4			28	5	5	6	12	SPT-03
5			31	6	8	8	16	SPT-04
6			26	9	9	8	17	SPT-05
7		SILTY CLAY Brownish grey, stiff to very stiff, medium to low plastic, wet	27	9	10	12	22	SPT-06
8			29	8	12	14	26	SPT-07
9			25	12	12	18	30	SPT-08
10			30	17	15	15	30	SPT-09
11			32	13	16	12	28	SPT-10
12			28	11	22	10	32	SPT-11
13			24	18	16	22	38	SPT-12
14		SILTY CLAY Grey, very stiff, medium to low plastic, wet	25	15	20	21	41	SPT-13
15			WS	12	18	19	37	SPT-14
16			37	19	21	20	41	SPT-15
17			34	18	22	24	46	SPT-16
18–19			28	16	18	26	44	SPT-17

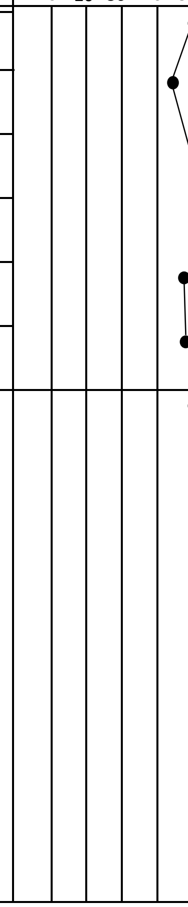
PENETRATION RESISTANCE



FOR SOIL/ OVERBURDEN	FINES						COARSE				
	<2	2-4	4-8	8-15	15-30	>30	<4	4-10	10-30	30-50	>50
	v.soft	soft	firm	stiff	v.stiff	hard	v.loose	loose	m.dense	dense	v.dense
FOR ROCK RQD (%)	<25	25-50	50-75	75-90	90-100						
	Very Poor	Poor	Fair	Good	Excellent						

DEPTH (m)	SOIL GROUP	LEGEND	SUBSURFACE DESCRIPTION	SAMPLE LENGTH (cm)	SPT BLOWS PENETRATION 6"	6"	6"	SPT N-VALUE	REMARKS
20	CL			25	13	25	25	50	SPT-18
21	CL		LEAN CLAY Grey, very stiff to hard, medium to low plastic, wet	30	17	25	20	45	SPT-19
22	CL			22	20	28	24	52	SPT-20
23	CL			31	19	30	26	56	SPT-21
24	CL			29	24	22	26	48	SPT-22
25	CL			24	20	25	24	49	SPT-23
			BOTTOM OF BOREHOLE	23	22	27	31	58	SPT-24

PENETRATION RESISTANCE



FOR SOIL/ OVERBURDEN	FINES						COARSE				
	<2 v.soft	2-4 soft	4-8 firm	8-15 stiff	15-30 v.stiff	>30 hard	<4 v.loose	4-10 loose	10-30 m.dense	30-50 dense	>50 v.dense
FOR ROCK RQD (%)	<25 Very Poor	25-50 Poor	50-75 Fair	75-90 Good	90-100 Excellent						

BOREHOLE LOG

pioneer associates

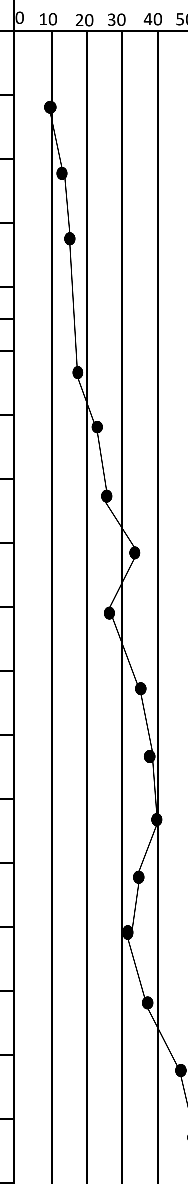
BOREHOLE NO.	BH-17
ELEVATION:	12 m

PROJECT: CONSULTANCY SERVICES FOR 132 KV TRANSMISSION LINE AND GRID STATIONS INCLUDING DESIGN, CONSTRUCTION, SUPERVISION AND ALLIED ACTIVITIES AND TESTING & COMMISSIONING FOR INTERCONNECTION OF ISOLATED MAKRAN AREA WITH NATIONAL GRID	LOCATION: Gwadar to Turbat
N: 2796716 m	E: 457831 m
JOB NO: PA / GI / 20 / 927	CLIENT: QESCO
CONSULTANT: M/S ENMASSE PVT LTD	
DATE STARTED: 5/3/2020	DATE COMPLETED: 5/3/2020

DRILLING INFORMATION		GROUND WATER			
DRILLING METHOD / EQUIPMENT: Straight Rotary		DATE	TIME	WATER DEPTH (m)	CASING DEPTH
DRILLING DEPTH: 20 m	DIA OF DRILLING: 6 inches	6/3/2020	---	0.8	---
CORE BARREL: NX- Double Tube	BIT: Fish Bit - Tungsten Carbide	DRILLER: M ASLAM			
SAMPLER: S.P.T / C.P.T	Wt. of SPT Sampler : 63.5kg; DROP: 75 cm	SITE GEOLOGIST: ABDUL WAHID		CHECKED BY: SALMAN AYUB	

DEPTH (m)	SOIL GROUP	SUBSURFACE DESCRIPTION	SAMPLE LENGTH (cm)	SPT BLOWS PENETRATION 6"	6"	6"	SPT N-VALUE	REMARKS
0–1	CL-ML	SILTY CLAY Grey, medium to low plastic, moist, stiff, medium dry strength						
1–2			38	5	5	5	10	SPT-01
2–3			34	7	5	7	12	SPT-02
3–4			28	6	7	8	15	SPT-03
4–5			30	SHELLBY TUBE				UDS-01 @ 4.0m
5–6	CL	LEAN CLAY Grey, stiff, medium to low plastic, wet	27	8	10	8	18	SPT-04
6–7			26	9	10	12	22	SPT-05
7–8			29	8	10	15	25	SPT-06
8–9			22	10	15	18	33	SPT-07
9–10		LEAN CLAY Grey, very stiff, medium plastic, wet	28	12	18	10	28	SPT-08
10–11			24	15	17	18	35	SPT-09
11–12			28	12	18	20	38	SPT-10
12–13		SANDY LEAN CLAY Greyish brown, very stiff, low plastic, wet	30	15	20	20	40	SPT-11
13–14			32	18	20	15	35	SPT-12
14–15			27	15	20	12	32	SPT-13
15–16			47	12	19	19	38	SPT-14
16–17		LEAN CLAY Greyish brown, very stiff to hard, medium to low plastic, wet	22	20	24	22	46	SPT-15
17–18			25	18	22	28	50	SPT-16

PENETRATION RESISTANCE



FOR SOIL/ OVERBURDEN	FINES						COARSE				
	<2	2-4	4-8	8-15	15-30	>30	<4	4-10	10-30	30-50	>50
	v.soft	soft	firm	stiff	v.stiff	hard	v.loose	loose	m.dense	dense	v.dense

FOR ROCK RQD (%)	<25	25-50	50-75	75-90	90-100
	Very Poor	Poor	Fair	Good	Excellent

DEPTH (m)	SOIL GROUP	LEGEND	SUBSURFACE DESCRIPTION	SAMPLE LENGTH (cm)	SPT BLOWS PENETRATION 6"	6"	6"	SPT N-VALUE	PENETRATION RESISTANCE 0 10 20 30 40 50	REMARKS
19	CL			29	16	20	22	42		SPT-17
20			LEAN CLAY Brown, very stiff to hard, medium to low plastic, wet	27	15	26	22	48		SPT-18
			BOTTOM OF BOREHOLE	25	15	22	29	51		SPT-19

FOR SOIL/ OVERBURDEN	FINES						COARSE				
	<2 v.soft	2-4 soft	4-8 firm	8-15 stiff	15-30 v.stiff	>30 hard	<4 v.loose	4-10 loose	10-30 m.dense	30-50 dense	>50 v.dense
FOR ROCK RQD (%)	<25 Very Poor	25-50 Poor	50-75 Fair	75-90 Good	90-100 Excellent						

BOREHOLE LOG

pioneer associates

BOREHOLE NO.	BH-18
ELEVATION:	24 m
N:	2799334.00 m
E:	460940.00 m

PROJECT: CONSULTANCY SERVICES FOR 132 KV TRANSMISSION LINE AND GRID STATIONS INCLUDING DESIGN, CONSTRUCTION, SUPERVISION AND ALLIED ACTIVITIES AND TESTING & COMMISSIONING FOR INTERCONNECTION OF ISOLATED MAKRAN AREA WITH NATIONAL

LOCATION: Gwadar to Turbat

JOB NO:	CLIENT:	CONSULTANT:	DATE STARTED	DATE COMPLETED
PA / GI / 20 / 927	QESCO	M/S ENMASSE PVT.LTD	24/02/2020	26/02/2020

DRILLING INFORMATION

DRILLING METHOD / EQUIPMENT:	Straight Rotary
DRILLING DEPTH:	20 m
DIA OF DRILLING:	6 inches
CORE BARREL:	NX- Double Tube
BIT:	Fish Bit - Tungsten Carbide
SAMPLER:	S.P.T
Wt. of SPT Sampler :	63.5kg
DROP:	75 cm

GROUND WATER

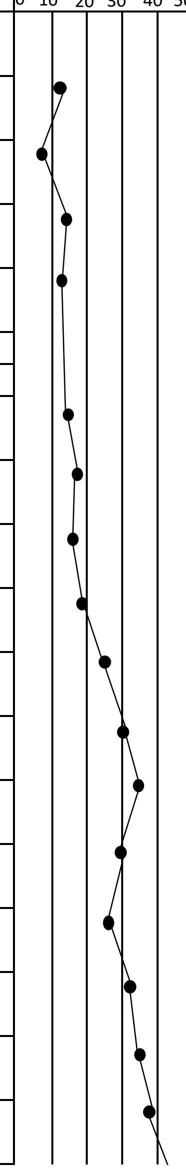
DATE	TIME	WATER DEPTH (m)	CASING DEPTH
27/02/2020	---	1.0	---

DRILLER: M ZOHAIB

SITE GEOLOGIST: ABDUL WAHID CHECKED BY: SALMAN AYUB

DEPTH (m)	SOIL GROUP	SUBSURFACE DESCRIPTION	SAMPLE LENGTH (cm)	SPT BLOWS PENETRATION 6"	6"	6"	SPT N-VALUE	REMARKS
1–2	ML	SANDY SILT Grey, stiff, non-plastic, moist	39	4	6	5	11	SPT-01
2–6	CL-ML	SILTY CLAY Greyish light brown, stiff, medium to low plastic, wet	38	5	5	4	9	SPT-02
			34	5	7	6	13	SPT-03
			30	8	6	5	11	SPT-04
			29	SHELLBY TUBE				UDS-01 @ 5.0m
6–10	SM	SILTY SAND Grey, non-plastic, moist	31	7	5	8	13	SPT-05
			29	9	10	8	18	SPT-06
			26	8	9	8	17	SPT-07
			25	10	10	9	19	SPT-08
10–18	CL	LEAN CLAY Greyish brown, stiff to very stiff, medium to low plastic, wet	27	11	15	10	25	SPT-09
			22	10	18	12	30	SPT-10
			27	15	14	20	34	SPT-11
			25	16	13	17	30	SPT-12
			30	15	14	14	28	SPT-13
			28	13	20	12	32	SPT-14
			32	18	15	20	35	SPT-15
			35	16	18	21	39	SPT-16

PENETRATION RESISTANCE



FOR SOIL/ OVERBURDEN	FINES						COARSE				
	<2 v.soft	2-4 soft	4-8 firm	8-15 stiff	15-30 v.stiff	>30 hard	<4 v.loose	4-10 loose	10-30 m.dense	30-50 dense	>50 v.dense
FOR ROCK RQD (%)	<25 Very Poor	25-50 Poor	50-75 Fair	75-90 Good	90-100 Excellent						

DEPTH (m)	SOIL GROUP	LEGEND	SUBSURFACE DESCRIPTION	SAMPLE LENGTH (cm)	SPT BLOWS PENETRATION 6"	6"	6"	SPT N-VALUE	PENETRATION RESISTANCE 0 10 20 30 40 50	REMARKS
19	CL			24	15	21	21	43		SPT-17
20			LEAN CLAY Grey, very stiff, medium to low plastic, wet	22	12	22	18	40		SPT-18
			BOTTOM OF BOREHOLE	26	18	25	23	48		SPT-19

FOR SOIL/ OVERBURDEN	FINES						COARSE				
	<2	2-4	4-8	8-15	15-30	>30	<4	4-10	10-30	30-50	>50
	v.soft	soft	firm	stiff	v.stiff	hard	v.loose	loose	m.dense	dense	v.dense

FOR ROCK RQD (%)	<25	25-50	50-75	75-90	90-100
	Very Poor	Poor	Fair	Good	Excellent

BOREHOLE LOG

pioneer associates

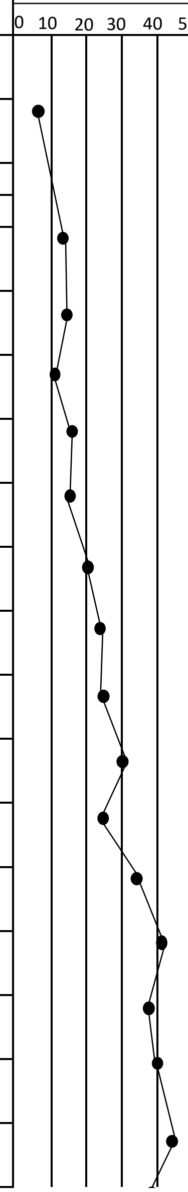
BOREHOLE NO.	BH-19
ELEVATION:	49 m

PROJECT: CONSULTANCY SERVICES FOR 132 KV TRANSMISSION LINE AND GRID STATIONS INCLUDING DESIGN, CONSTRUCTION, SUPERVISION AND ALLIED ACTIVITIES AND TESTING & COMMISSIONING FOR INTERCONNECTION OF ISOLATED MAKRAN AREA WITH NATIONAL	LOCATION: Gwadar to Turbat	N: 2800943.00 m E: 464575.00 m

JOB NO:	CLIENT:	CONSULTANT:	DATE STARTED	DATE COMPLETED
PA / GI / 20 / 927	QESCO	M/S ENMASSE PVT.LTD	24/2/2020	26/2/2020

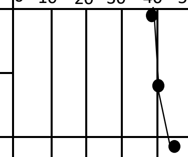
DRILLING INFORMATION				GROUND WATER			
DRILLING METHOD / EQUIPMENT: Straight Rotary				DATE	TIME	WATER DEPTH (m)	CASING DEPTH
DRILLING DEPTH: 25 m	DIA OF DRILLING: 6 inches			27/02/2020	---	1.0	---
CORE BARREL: NX- Double Tube	BIT: Fish Bit - Tungsten Carbide			DRILLER: M ZOHAIB			
SAMPLER: S.P.T / C.P.T	Wt. of SPT Sampler : 63.5kg	DROP: 75 cm		SITE GEOLOGIST: ABDUL WAHID		CHECKED BY: SALMAN AYUB	

DEPTH (m)	SOIL GROUP	LEGEND	SUBSURFACE DESCRIPTION	SAMPLE LENGTH (cm)	SPT BLOWS PENETRATION 6"	6"	6"	SPT N-VALUE	PENETRATION RESISTANCE	REMARKS
1	ML		SANDY SILT Greyish brown, stiff, non plastic, moist							
2				35	5	4	4	8		SPT-01
3				27	PITCHER TUBE					UDS-01 @ 2.0m
4	SM		POORLY GRADED SAND WITH SILT Light grey, medium dense, non-plastic, wet	30	5	5	7	12		SPT-02
5	SM		SILTY SAND Grey, medium dense, non plastic, wet	32	7	7	6	13		SPT-03
6				30	5	5	6	11		SPT-04
7	SP		POORLY GRADED SAND Light Grey, non-plastic, wet with trace gravels	27	8	8	8	16		SPT-05
8	SM		SILTY SAND Grey, low plastic, wet	29	10	7	8	15		SPT-06
9	SP		POORLY GRADED SAND Grey, non-plastic, moist	20	10	12	8	20		SPT-07
10				26	12	10	14	24		SPT-08
11				25	10	15	10	25		SPT-9
12				30	11	17	13	30		SPT-10
13				32	13	10	14	24		SPT-11
14				28	12	15	17	32		SPT-12
15	ML		SANDY SILT Brownish grey, non-plastic, wet with trace gravels	25	15	22	19	41		SPT-13
16				30	17	20	19	39		SPT-14
17				32	16	18	22	40		SPT-15
18	CL		LEAN CLAY Grey, medium to low plastic, moist	27	18	22	22	44		SPT-16



FOR SOIL/ OVERBURDEN	FINES						COARSE				
	<2	2-4	4-8	8-15	15-30	>30	<4	4-10	10-30	30-50	>50
	v.soft	soft	firm	stiff	v.stiff	hard	v.loose	loose	m.dense	dense	v.dense

FOR ROCK RQD (%)	<25	25-50	50-75	75-90	90-100
	Very Poor	Poor	Fair	Good	Excellent

DEPTH (m)	SOIL GROUP	LEGEND	SUBSURFACE DESCRIPTION	SAMPLE LENGTH (cm)	SPT BLOWS PENETRATION 6"	6"	6"	SPT N-VALUE	PENETRATION RESISTANCE 0 10 20 30 40 50	REMARKS
19	SP		POORLY GRADED SAND Grey, non-plastic, moist	28	15	16	24	40		SPT-17
20				22	14	22	19	41		SPT-18
			BOTTOM OF BOREHOLE	24	18	20	25	45		SPT-19

FOR SOIL/ OVERBURDEN	FINES						COARSE				
	<2	2-4	4-8	8-15	15-30	>30	<4	4-10	10-30	30-50	>50
	v.soft	soft	firm	stiff	v.stiff	hard	v.loose	loose	m.dense	dense	v.dense
FOR ROCK RQD (%)	<25	25-50	50-75	75-90	90-100						
	Very Poor	Poor	Fair	Good	Excellent						

ANNEXURE-D

FORM OF PERFORMANCE GUARANTEE FOR THE PAINTING SYSTEM
(on Stamp Paper)

Dear Sir,

KNOW ALL MEN by these presents that Messer's a Company established and existing under and by virtue of the Laws of Pakistan and having its registered office in
----

(hereinafter referred to as CONTRACTOR and QUETTA ELECTRIC SUPPLY COMPANY, having its registered office in Quetta (hereinafter referred to as CLIENT) have already entered into a Contract Agreement on
----

for goods and services for the transmission lines of Transmission System Expansion Projects.

WHEREAS THE CONTRACTOR has to provide painting system for the transmission line towers as per General Project Requirements of this bidding documents. The CONTRACTOR therefore hereby confirms that based on years of research work and experience over decades of the Paint Company, the correctly applied coating system and the conditions known to the Contractor
----

a) Painting System will have a life time of rust and corrosion protection of fifteen (15) years for lower parts and twenty (20) years for the upper parts of the towers/poles.

b) Painting System will have a guaranteed life of five (5) years for all parts of the towers/poles.

WHEREAS to fulfill the obligations by the CONTRACTOR,

I. Test panels will be prepared at site in presence of QESCO, CONTRACTOR and the Paint Company.

II. The Client will ensure that the painting system will not be damaged during routine maintenance of the transmission line and, if damaged, will be repaired as per procedure outlined by the Paint Company which is attached to this guarantee.

III. If there is any major defect in the painting system which can be traced back to the paint, either repair of the damaged areas or a recurring replacement of material or amount proportional to the damaged areas will be made by the CONTRACTOR which in any case will not exceed the preminal coating paint.

IV. The option to repair the damage or replacement of material or amount rests with CONTRACTOR.

The CONTRACTOR agrees to keep this GUARANTEE in full force from the date of provisional acceptance of the transmission lines for five (5) years of guaranteed life of the painting system, for fifteen (15) years life time of the corrosion and rust protection of the towers/poles and twenty (20) years life time of rust and corrosion protection for the upper parts of the towers/poles.

This Guarantee shall be binding on the CONTRACTOR and his successors and shall be irrevocable.

WITNESSES

1.

for and on behalf of,
(Name of Contractor)

2.

for and on behalf of,
(Name of Contractor)

SECTION-04

TECHNICAL PROVISIONS FOR CONSTRUCTION OF TRANSMISSION LINES

1. GENERAL

The Technical Provisions of Constructions of t/line, in general has been attached. The relevant clauses of Second circuit stringing work & all other allied works which shall be considered essentials by QESCO/Consultant, shall be applicable.
After completion of stringing activities, the contractor is liable to submit the Plan and Profile generated on PLS-CADD software, in .xyz format, including (BAK File) and Hard Copies.

(1) Clearing Right-of-Way

Right-of-Way clearing shall be restricted to the minimum necessary for the safe construction and operation of the line. Clearing shall generally consist of brushing out the center line, tower locations and conductor pulling sites within 15 meters on each side of the center line. Trees over 2.5 meters in height which constitute a hazard or danger to the transmission line, or whose tops are within 6 meters of the 65°C final conductor position shall be removed.

The clearing of desert vegetation shall be restricted to that required for placement of footings and for the assembly and erection of towers and wire pulling Site.

No clearing will be allowed in orchards or other areas of fruit bearing trees, except as specifically approved by the Engineer.

The cleared materials will be the property of the Land Owner. If any disposal of cleared material is required it will be disposed off by burning or other methods approved by the Engineer.

(2) Detailed Check Survey

The indicative drawing showing the line route and substation's locations are attached in Section-5 (Volume-2) of Specification Drawings.

The contractor shall conduct the check survey to locate tower locations on ground conforming to ensure that ground features, angle deviations, levels, distances, clearances, crossings correspond are maintained. Any variance shall be noted and marked by the contactor. The requirement of tower site leveling and revetment work, if required, shall also be marked by the contractor on the profiles. Locations, where benching might be required, shall also be identified. Contractor shall make contour measurements along with the calculations for the volume of benching and revetment, so that a decision can be made whether to accept benching and/or use unequal leg extensions. The co-ordinates of all the tower locations shall also be recorded using GPS/DGPS of positional accuracy less than 1m for easy relocating which shall be incorporated in the final digitized route alignment/profile.

After completing the check survey, profiles shall be re-submitted to the Employer for approval along with check survey report.

The contractor will be responsible for the correct setting of towers as shown in approved profiles. If towers after erection are found to be out of the approved alignment/position in the profile, the Contractor will dismantle and re-erect them correctly fully at his own cost and without extension of time.

The contractor shall be responsible to carry out survey including pegging out and layout of tower locations, spotting/staking of towers and preparation of construction structure list.

The work to be done by the Contractor shall include but not limited to the following:

(i) Validation & updating of the already prepared plan & profile drawings and construction structure lists of the proposed transmission line route with the prevailing field developments. Staking (center and reference pegs) of the tower locations which have to be concreted are included in the Contractor's scope.

Latitude and longitude by hand held GPS of each angle location should be collected and submitted to the Engineer.

(ii) In case of route diversion, detail survey shall be conducted and approved by the Engineer, the Contractor will carry out investigation of diversion route along with necessary plan tabling of the area and shall make necessary modification and establish the terminal points, the angle locations, road crossing and other points of interest as advised by the Engineer or his authorized representative.

(iii) The contractor shall also be responsible to prepare plan tabling and profile drawings, tower spotting and construction structure list of any diversion route.

(iv) The Contractor shall obtain necessary rules and regulations. Survey of Pakistan maps will be shown to the successful bidder in the office of the Engineer when requested.

(v) The line route will be marked on the ground with permanent concrete markers. The Contractor will install the concrete markers of at least 130 x 150 mm at top and bottom with a height not less than 1m. The markers shall be buried 0.5 m below existing ground level. The markers shall be white washed and a red point shall be made on the top of the marker to indicate the exact center of the line. This point shall be further encircled by red paint.

(3) **Tower Staking**

Tower centers shall be staked in the field along with two reference stakes on either side of the tower along the line route, using wooden pegs. All angle tower locations shall be bisected.

It shall be the contractor's responsibility to supply the construction engineering not specifically reserved for the Engineer in these specifications.

2 Sub Soil Investigation

The Work specified herein is to determine the type and geotechnical characteristics of the foundation strata to the specified depth and location. This is to be accomplished through wash boring or rotary drilling, field testing, ground water observations, soil sampling and laboratory testing. The location of investigation boreholes on the ground shall be established by the Contractor in accordance with the Drawings and from reference points to be provided by the Engineer as per requirement.

1. All Angle and Dead-end towers	15 meters
2. Every ninth Tangent tower	10 meters
3. Any other specific tower location	upto 40 meters as approved by the Engineer.

(a) **Method of Drilling**

Drilling shall be done by rotary or wash boring method or the combination of two methods by means of which a hole of specified diameter is extended in depths. Use of bottom discharge drilling bit shall not be permitted. The contractor shall be allowed to use percussion method where gravels & boulders are encountered.

(b) **Drilling of boreholes in flowing water conditions**

Drilling may be carried out under water conditions. During the investigation, the Engineer may change such locations to land drilling depending upon the prevailing water way conditions.

(c) **Test Pit**

The test pits shall be excavated at the locations as specified by the Engineer. Excavations of test pits shall be made to the depths as directed by the Engineer by manual labor and with the help of suitable digging tools. Test pits shall generally be excavated to a depth of about 3 meters below the ground surface or bed rods whichever is encountered earlier.

(d) **Drilling Fluid**

The drilling fluid used for rotary drilling or wash boring shall be clean water clear from suspended sediments. The Contractor may use the natural or commercial drilling mud/bentonite slurry as drilling fluid.

(e) **Casing of Boreholes.**

(i) Casing of a required size allowing entry of sampling tools shall be used in conjunction with drilling to wall the boring to the bottom of the hole.

(ii) The casing shall be made of cylindrical steel pipes and shall have sufficient strength so as to maintain position and shape during drilling operations.

(iii) The casing may be omitted only where it can be shown to the satisfaction of the Engineer/Engineer's Representative that sampling operations without the casing will not entrain soils from an elevation higher than the depth at which field testing or sampling is to be made.

(iv) It shall be the Contractor's responsibility to pull out casing from the bore holes after its completion for which no extra payment shall be made.

(f) **Field Testing**

Field testing shall include Standard Penetration Test. Standard Penetration Test shall conform to ASTM D-1586. This designation describes as procedure to obtain a record of the resistance of subsoils to the penetration of a standard sampler and to obtain representative disturbed samples of the material for identification purposes and laboratory testing. The penetration resistance shall be expressed as the number of blows of a 63.4 kg (140 Lbs) hammer freely dropping 762 mm (30 inches) required forcing the standard sampler 305 mm (12 inches) into the soil. Standard Penetration Tests shall be conducted in the bore holes at one meter interval from 1 meter depth to 10/15 meter depth of bore hole and upto 40 m in case of river crossing locations, unless otherwise directed by the Engineer. Immediately after each penetration test a representative portion of the soil core shall be placed in moisture proof container.

(g) **Undisturbed Sampling**

The undisturbed samples shall be taken in cohesive and non-cohesive materials. Samples shall be obtained using Denison or Pitcher sampler or equivalent double tube core barrel or shelby tube. The sampling procedure shall conform to latest B.S.S/ASTM Standards. The length of undisturbed samples obtained shall not be less than 30 cm. immediately upon extraction from the hole, the sample shall be properly waxed. The number and depth of undisturbed samples from each hole shall be as directed by the Engineer during the progress of the drilling work at site.

(h) **Labeling and Disposition of Samples**

Each sample shall have identification tags giving information regarding Sample No., Top Elevation of Hole, Date of Sampling, Depth and Length of Sample, and Description of Sample.

All the samples shall be delivered to the Engineer's Representative at his office at the site. The selected undisturbed and disturbed samples shall be carefully transported by the Contractor to the approved testing laboratory for testing. Every precaution shall be taken to avoid damage to samples as a result of careless handling and undue delay in transportation. The tubes containing undisturbed samples shall be well packed in wooden boxes to protect the samples against vibration.

(i) **Ground Water Observations**

Whenever required by the Engineer, bore holes shall be preserved for observations of ground water conditions. When the borings are advanced by using natural or commercial drilling mud/bentonite to stabilize the hole, the hole shall be flushed thoroughly with clean water at the completion of boring for the purpose of observing ground water levels.

(j) **Laboratory Tests**

(i) **General**

- The laboratories in which the samples are to be tested shall be approved by the Engineer.
- The Engineer's Representative shall have access to the laboratories to supervise and check the laboratory testing of the samples.
- The testing shall be carried out in accordance with ASTM or equivalent British Standards, or as directed by the Engineer.

(ii) **Tests**

The Contractor shall arrange to carry out laboratory tests on the specified samples of the subsoil material. The samples to be tested and the test to be carried out for each sample shall be specified by the Engineer. Laboratory testing may include but is not limited to the tests listed below:

- Grain Size Analysis (Sieve + Hydrometer)
- Atterberg's Limits
- Chloride Content (soil and water)
- Natural Moisture Content
- Bulk and Dry Densities
- Organic Matter Content
- Sulphate Content (soil and water)
- PH value (soil and water)
- Unconfined Compression Test
- Direct Shear Test
- Consolidation Test
- Total Soluble Salts.

(k) **Confirmatory Sub-soil Investigation**

After preliminary subsoil investigations confirmatory investigation upto maximum depths of 25 meters will be carried out by the contractor. The location of selected confirmatory investigation will be conveyed to the Contractor by the Engineer.

(l) **Decision on the Type of Foundation to Be Made**

After soil investigation, based upon the results, the contractor will propose foundation type for each location as per the actual site data and submit for the approval of Engineer. After approval of Engineer, the work will be executed at site. The contractor will intimate to the Engineer about any change in the already approved design/ work before the execution of the work at site and will not do any such work without prior approval.

3. Foundation Requirements

(1) **General**

The items of the Bid Schedule for constructing the various types of concrete foundations (including pile foundation) for steel towers include the following:

(a) Performing all clearing and leveling as required to construct the footings and erect the steel towers and poles.

(b) Performing all required excavation, dewatering, shuttering, compacting backfill for the concrete footings.

(c) Installing steel stub angles for towers in the concrete footings.

(d) Tower grounding before placement of concrete.

(e) All concrete work for the concrete footings, including the cost of furnishing all reinforcing bars, and all materials for concrete.

(f) Installing pile foundations where required.

The specific requirements for performing the individual portions of the work to construct the concrete foundations are included in the paragraphs pertaining to the individual work to be performed.

(2) **Excavation for Tower Footings**

The Contractor shall perform all excavation required for constructing various types of concrete foundations for the steel towers.

The tower sites shall be leveled and cleared of trees, brush and stumps as may be required to construct the tower footings and to erect the steel towers. Cleared materials shall be disposed of as directed by the Engineer/Engineer's Representative.

All excavations shall be sufficient to provide concrete footings with dimensions not less than shown on the drawings.

After the Contractor has excavated the footing to the required depth, the Engineer or the Engineer's representative will inspect the bottom of the excavation and determine if the bearing material is suitable for the type of footing designated for that location. If it is found that the bearing material is unsatisfactory for the type of footing designated, the Engineer or the Engineer's representative will either designate another type of footing or ask for compacted crushed stone mixed with sand to be placed underneath the footing for a depth of upto 1.2 meters. The contractor will be paid only for the type of footing actually installed.

A maximum variation of 60 mm above or below established grade will be permitted. However, if excavations are below specified grade plus tolerance, those shall be backfilled to required grade by the Contractor with the Contractor's furnished concrete at his own cost. No payment will be made to the replaced material underneath the footing.

All excavated material which is suitable for backfilling shall be laid aside to be used for backfilling at the tower site from which it was excavated, and the excess material shall be spread evenly around the site as directed by the Engineer/Engineer's Representative.

Concrete shall be placed as soon as practicable after each excavation is completed and all excavations shall be protected so as to maintain a clean sub-grade until the footing is placed, using dewatering, timbering, shoring, or casing, as necessary. Any sand, mud, silt, or other objectionable material which may accumulate in the excavation shall be removed at the expense of the Contractor before placing concrete. After completion of foundations all the dewatering holes shall be filled with dry sand.

(3) **Rock Excavation**

Rocks shall be excavated to the depth required to provide suitable base for the foundations as indicated on relevant drawings. Rocks are classified as sound and mashes, layers or ledges of mineral material 0.241 cubic meters in volume in place and of such hardness and texture that it cannot be easily loosened or broken down.

Rock excavation includes drilling, blasting, removal drainage and pumping as required. Drilling and blasting techniques shall keep over break to a minimum and no extra compensation shall be paid for the removal of over broken material. The contact surface of the rock shall be cleared of all loose rock and soil.

The cost of any damage whatsoever caused by blasting shall be payable by the Contractor. He shall not be relieved of these costs in spite of having received approval of his methods from the Engineer.

(4) **Erosion/Slope Protection**

For erosion protection against water current, gravel blankets shall be placed such that they do not flow away with water current. These gravel blankets shall be placed at or adjacent to tower sites in the manner as directed by the Engineer/Engineer's Representative. Gravel for the blankets shall be furnished by the contractor, and it shall be pit-run, free draining, containing no stones larger than 635 mm size obtained from the closest source approved by the Engineer/Engineer's Representative. The gravel shall be reasonably clean and free from vegetation, pieces of timber, or other foreign matter, and shall be distributed and graded evenly over the required areas. No compaction will be required.

Slope protection will be provided for foundations which are located/placed on uneven ground and/or they are partially or fully exposed in such a way that designed burden cannot be provided on these foundations safely. Slope protection shall include but not limited to construction of retaining walls of stone or brick masonry or stones in gabion boxes to a height and depth so as to provide adequate protection and necessary burden by making a leveled platform with or without brick/stone mortar lining after filling with earth as per specifications/drawings or as directed by the Engineer.

(5) **Concrete Foundations**

Each tower foundation will have four footings and each footing will consist of a steel stub angle embedded in reinforced concrete. The footings for each tower in a tangent section of the line shall be placed so that the longitudinal axis of the tower cross-arm will lie in a plane perpendicular to the traverses of the line. Unless otherwise directed by the Engineer, the footings for each angle tower shall be placed so that the tower cross-arm will lie in a plane bisecting the interior angle formed by the inter-section of the traverses of adjacent sections of the line.

The footings at the various tower sites shall be constructed in accordance with the criteria shown on Drawings.
Pile foundations will be required where the field and laboratory tests confirm the requirements. The pile foundations will be installed as shown on the relevant drawings and in accordance with these specifications.

All pile foundations as shown on drawings are of preliminary nature and depths of piles have been indicated for bidding only. The final design may vary with respect to the length and diameter of pile and other details shown on drawings.

Any type of spread footing foundation may be changed to another type of spread footing foundation or pile foundation in accordance with field requirements during execution of the project.

(6) **Placing of Stub Angles in Footings**

Stub angles shall be placed in the tower footings and shall be supported in the proper position by means of a rigid frame or equivalent suitable device to ensure placement of the stubs within the tolerances specified below. The stub angles shall be held rigidly in a manner to prevent displacement during placing of concrete.

All stub angles for the tower legs shall be set accurately to the grade and alignment designated on the drawings and as directed by the Engineer. Work that is not within the tolerance will be corrected as directed by the Engineer, and at the Contractor's expense. The setting tolerances following complete foundation installation including backfilling and compacting are as follows:

(a) Tower Center from theoretical location:

(i) Transverse ± 150 mm

(ii) Longitudinal ± 500 mm

(b) Tower Orientation (angular departure from the theoretical location measured at the point of intersection of a tower face and the longitudinal center-line)
25 mm

(c) Difference in Elevation between working point marks on Stub Angles including diagonally opposite legs 8 mm

(d) Departure from theoretical Horizontal Dimensions between tower center line and working point marks on stub angle:

(i) Along the tower face ±5 mm

(ii) Along the tower diagonal ±7 mm

(e) Batter 5mm/m

(f) Twist (about heel of stub angle) 2°

(7) **Tower Grounding**

Each tower shall be grounded by installing one ground rod below each of two footings. Ground rods shall be driven at least 2.5 meters into undisturbed soil at the bottom of the footing excavation, as shown on the drawings. The ground rod shall be connected to the stub angle by a 6.5mm dia copper ground wire. The connection of this wire to the ground rod and to the stub angle shall be made by a bolted clamp in accordance with the drawings.

Where it is not possible to drive a ground rod an alternative grounding by installing 'crowfoot' be adopted.

The resistance of the two rods/crowfoot in parallel shall be measured and recorded before concrete footings are poured. If the resistance is more than 10 ohms, additional rods/crowfoot shall be installed as directed by the Engineer/Engineer's Representative. No extra payment would be allowed on account of this.

The dead end terminal tower of the overhead lines must be connected to the earthing system of the grid stations.

(8) **Concrete**

(a) **General**

All concrete and reinforcement placed for tower footings shall conform to the requirements of this section.

At least 30 days prior to beginning concrete placement, the Contractor shall submit to the Engineer for approval, a design mix (along with quantity and source of each material) along with six (6) test cylinders using the actual materials to be incorporated into the Work. Approval of the design mix will in no way relieve the Contractor from meeting all the requirements of these Specifications. Whenever the Contractor proposes to use a different material source, a new design mix must be submitted and approved as outlined above. During construction if in the Engineer's opinion the mix should be adjusted, the Contractor shall submit a new design mix as directed by the Engineer.

(b) **Materials**

The contractor shall furnish all materials for use in concrete, including but not limited to cement, sand, coarse aggregate, water, reinforcing bars, air-entraining agent and concrete curing compound. Air-entraining agent and curing compound shall be accepted on manufacturer's certification of compliance with specification requirements. However, the Engineer reserves the right to require submission of and to perform tests on samples of the agent and/or compound prior to shipment and use in the Work at the cost of Contractor. If the Contractor purchases cement from within the country, EMPLOYER shall help arrange cement allotments for the contractor, but in no way be responsible for the timely supply of cement, nor for the quantity needed by the Contractor.

(i) **Cement**

Cement shall meet the requirements of ASTM C-150 and shall meet the false-set limitation specified therein. The cement shall be free from lumps and damaged cement, when used in concrete. Adequate provisions shall be made to prevent absorption of moisture when cement is stored. Cement Type I shall be used for all types of foundations other than those for which sulphate resistant cement type V is required by the Engineer. No extra payment would be made to the Contractor in case sulphate resistant cement is used.

(ii) **Sand and Coarse Aggregate**

Sand and coarse aggregate shall be furnished from any approved source. The sand particles shall be clean, hard, dense, durable, uncoated rock fragments that will pass a screen having 6.5 mm square openings. The sand shall be well graded from fine to coarse and shall be free from injurious amounts of dirt, organic matter, and other deleterious substances.

The coarse aggregate shall consist of clean, hard, dense, durable, uncoated rock fragments, shall be free from injurious amounts of flat and elongated pieces, organic matter, or other deleterious substances. The maximum size of crushed coarse aggregate for piles shall be 19 mm and for spread footings 38 mm or as directed by the Engineer. The grading of these sizes shall conform to ASTM C-33.

The Contractor shall submit, for testing and approval, representative samples of the sand and coarse aggregate proposed for use in the concrete work. All aggregates shall conform to the requirements of ASTM C-33. During Construction the Contractor shall also arrange testing of sand and coarse aggregate if directed by the Engineer to determine compliance with Specifications. The cost of all laboratories testing of these samples shall be borne by the Contractor.

(iii) **Water**

Water shall be free from objectionable quantities of silt, organic matter, alkalies, salts or other impurities.

(iv) **Reinforcing Bars**

Reinforcing bars shall be deformed bars conforming to ASTM Designation A 615, Grade 40 except for tower type JKD where Grade 60 shall be used.

(v) **Curing Compound**

Curing compound shall be wax-base and white-pigmented.

(c) **Composition**

The Contractor shall determine the proportions of the sand, coarse aggregate, and cement needed to provide concrete, meeting the requirements of these Specifications, and shall be approved by the Engineer. Concrete which contains 38 mm maximum-size aggregate shall have a cement content of not less than 380 kgs per cubic meter, and concrete which contains 19 mm maximum size aggregate shall have a cement content of not less than 391 kg per cubic meter with one extra bag per cubic meter in case of water encountered during concreting of piles. 38 mm maximum size aggregate shall be used for spread footing and 19 mm aggregate for piles. The net water cement ratio by weight shall not exceed 0.5. Surface water contained in the aggregate shall be included as part of the mixing water in determining the water content. Reinforced concrete design will be checked in accordance with the ACI Building Code.

The Contractor will take three test cylinders per leg, and the average compressive strength at 28 days shall exceed 211 kg/cm^2 (3000 psi) and 281 kg/cm^2 (4000 psi) as the case may be and no individual test value should fall more than 35 kg/cm^2 (500 psi) from the minimum specified value.

The compressive strength of the concrete will be determined by the Engineer through the medium of test of (150 x 300 mm) cylinders made and tested in accordance with ASTM C-39. The Contractor shall furnish all necessary sampling equipment such as slump cones, test cylinders, etc. at the site. This equipment is to be approved by the Engineer/Engineer's Representative. The cost of the material lab tests shall be borne by the Contractor.

The use of calcium chloride in concrete will not be permitted.

The slump of the concrete shall not exceed 75 mm for conventional foundation, pile cap & tie beam and 150 mm for piles.

(d) **Batching and Mixing**

Unless specifically approved by the Engineer, all concrete used on the project shall be machine mixed. Hand mixing shall only be used when authorized by the Engineer, and shall be performed under his directions.

The sand and coarse aggregate shall be weighed and shall be proportioned on the basis of integral bags of cement unless the cement is weighed. After weighing, the materials may be proportioned on the basis of equivalent volumes. The Contractor shall provide equipment and shall maintain and operate the equipment as required to accurately determine and control the amount of each separate ingredient entering the concrete. Batching shall be such that combined inaccuracies in feeding and measuring the materials will not exceed 1.5 percent for water and weighed cement and 2 percent for sand and each size of coarse aggregate. The concrete shall be uniform in composition and consistency throughout the mixed batch, and from batch to batch, except where changes in composition or consistency are directed. The mixing time shall be at least 1.5 minutes for stationary mixers. Excessive Over-mixing requiring the addition of water to preserve the required consistency will not be permitted. The temperature of the concrete when it is being placed shall be not more than 35°C and not less than 5°C in moderate weather or 10°C when the mean daily temperature drops below 5°C. Truck mixers will be permitted only when the mixers and their operation are such that the concrete throughout the mixed batch and from batch to batch is uniform with respect to consistency and grading. Any concrete retained in truck mixers so long as to require additional water to permit satisfactory placing shall be wasted.

(e) **Forms Preparation for Placing of Concrete**

Unless otherwise provided for on the drawings or approved by the Engineer, all concrete placed will be monolithic.

Forms shall be sufficiently tight to prevent loss of mortar from the concrete and shall be maintained rigidly in position until the concrete has hardened sufficiently to prevent damage by forms removal. All surfaces of foundations upon or against which concrete is to be placed shall be free from standing water, mud and debris. The surfaces of absorptive foundations against which concrete are to be placed shall be moistened thoroughly so that moisture will not be drawn from the freshly placed concrete. The surfaces of construction joints shall be clean, rough and surface dry when covered with fresh concrete. Cleaning shall consist of the removal of all laitance, loose or defective concrete, coatings, sand, curing compound if used, and other foreign material. A mortar layer shall not be used on concrete construction joints.

The methods and equipment used for transporting concrete, and the time that elapses during transportation shall be such as will not cause appreciable segregation of coarse aggregate or slump loss in excess of 25 mm in the concrete as it is delivered into the Work. Concrete may be transported from the mixer to the forms and deposited in the forms by any method approved by the Engineer such as trucks, buckets, chutes and pumping. Aluminium pipe or chutes shall not be used for tremie trunk line, or chute for placing of concrete, or for the delivery of pumped concrete. Re tempering of concrete will not be permitted. Any concrete which has become so stiff that proper placing cannot be assured shall be wasted. Formed concrete shall be placed in continuous approximately horizontal layers, the depths of which generally shall not exceed 500 mm. Concrete shall be vibrated until it has been consolidated to the maximum practicable density, is free from rock pockets of coarse aggregate, and closes snugly against all surfaces of forms and embedded materials. Exposed unformed surfaces of concrete shall be brought to uniform surfaces and worked with suitable tools to a reasonably smooth wood float or steel-trowel finish as directed. Concrete in the tops of foundations in which stub angles are embedded shall be sloped to provide drainage away from the stub angles.

(f) **Reinforcement**

Steel reinforcing bars shall be placed in the concrete where shown on the drawings. Before reinforcement is placed, the surfaces shall be cleaned of heavy flaky rust, loose mill scale, dirt, grease, or other foreign substances. Reinforcement shall be accurately placed and secured in position so that it will not be displaced during placing of concrete.

The Engineer shall not furnish supplemental bar-placing diagrams, bar lists, and bar-bending diagrams. Any such additional diagrams and bar lists of this type which the Contractor may require to facilitate the fabrication and placement of reinforcement shall be provided by the Contractor.

Reinforcement will be inspected for compliance with requirements as to size, shape, length, splicing, position, and amount after it has been placed.

Any bar-placing diagrams, bar lists, and bar-bending diagrams prepared by the Contractor shall conform to the requirements shown on the reinforcement design drawings and shall be approved by the Engineer.

(g) **Protection and Curing**

The Contractor shall protect all concrete against injury until final acceptance.

The concrete shall be cured with two coats of approved membrane type curing compound to be applied as soon as possible after concrete placement and in no case later than 2 hours. Curing with water shall be used only as an alternative to the type curing and with Engineer's approval. The application of the curing compound shall be in accordance with the procedures outlined by the Manufacturer.

In exceptional cases where extremely corrosive soil conditions are encountered, or as directed by the Engineer, the surfaces of the concrete, both exposed and unexposed, shall be treated with an approved type of bituminous compound. A minimum of two applications shall be required, and the applications shall be 100 percent effective. Surfaces to be treated shall not be coated with curing compound. No extra payment shall be made on this account.

(h) **Repair of Concrete**

Any concrete that is damaged or defective from any cause; concrete that is honey-combed, fractured, or otherwise defective, and concrete damaged because of excessive surface depressions, must be excavated and built up to bring the surfaces to the prescribed lines, shall be removed and replaced and any imperfections and irregularities on concrete surfaces shall be corrected. The removal and replacement of damaged or defective concrete, and the correction of surface imperfections and irregularities shall be made with concrete dry pack, or mortar (Portland cement mortar), or at the option of the Contractor, with epoxy-bonded concrete, or epoxy-bonded epoxy mortar, where and as applicable for the type of repair involved. All repairs should be completed within 24 hours after removal of forms, and as directed by the Engineer or Engineer's representative. However, forms shall not be removed for a period of at least 24 hours after the concrete work until it has acquired sufficient strength to safely carry its own weight and any construction loads that may be imposed on it.

(i) **Tolerances for Concrete Construction**

The Contractor shall be responsible for setting and maintaining concrete forms within the tolerance limits necessary to insure that the completed Work will be within the tolerances specified or within good construction practices. Concrete work that exceeds the tolerance limits specified herein shall be inspected by the Engineer and he will determine what effect the deviations will have upon the structural action or operational function of the structure, and what remedies may be necessary. If after such inspection the Contractor is directed to remove or replace any defective Work, he will do so at his own expense.

(i) Tolerances for footings:

- Variation from plumb or specified batter for lines and surfaces of stems.	In any length of 3.0 meters .... 13 mm Maximum for entire length .... 26 mm
- Variation in cross-sectional dimensions of stems	Minus 7 mm Plus26 mm
- Variation from specified elevation for top of concrete	Minus 13 mm Plus13 mm
- Variation of dimension in plan	Minus 13 mm Plus52 mm
- Misplacement or	2 percent of the footing

Eccentricity	width in the direction of misplacement but not more than 52 mm
- Reduction in thickness	5 percent of specified thickness

(ii) Tolerance for placing reinforcing steel:

- Variation of protective covering:	with cover of 64 mm or less 7 mm
	with cover of more than
	64 mm .... 13 mm
- Variation from indicated spacing	.... 26 mm

(9) **Backfill for Tower Footings**

Backfill shall be placed about the tower footings to elevations indicated on the drawings or as directed. The material used for backfilling, the amount thereof, and the manner of depositing this material shall be approved by the Engineer. Where the excavated materials are insufficient in quantity or are not suitable, as determined by the Engineer's Representative, for use as backfill, the Contractor shall obtain suitable material from the borrow. No borrow pits shall be made within 25 meter radius from center of tower. Backfill shall be placed about the tower footings as soon as practicable after removal of concrete forms, but not earlier than 8 hours from application of sealing compound or bitumen coating to concrete surfaces.

The excavated material not suitable for backfilling or in excess of backfilling requirement shall be spread evenly over or adjacent to the Site. The backfill adjacent to footing stems shall be approximately 150 mm above the original ground, and shall be graded and sloped uniformly away from the stems so that there is no ponding at or around the footing.

In backfilling for concrete footings, the pad of the footing shall be covered with fine material of 300 mm thickness (after compaction) before any coarse material is deposited. Care shall be taken to avoid damage to the concrete when backfilling. The backfill material shall be clean and free from vegetation, pieces of timber, or other foreign matter. Suitable material for backfilling shall be a compatible granular material having granularities within the following limits.

Sieve	% Passing
76 mm (3 in)	100
No. 200	0-15

(10) **Compacting Backfill**

Backfill shall be placed in horizontal layers which after compaction shall not be more than 150 mm thickness. Each layer shall be compacted by tamping machines or other mechanical means approved by the Engineer.

Backfill shall be moistened properly where required. When excavated material is so wet that it is not suitable for backfilling, it shall be spread and aerated until the proper moisture content is attained, at which time the material shall be used as backfill around tower footings. The backfill material shall not be placed until all forms and timber used for shoring or bracing have been removed, unless otherwise permitted by the Engineer/Engineer's Representative.

The Contractor shall submit, for laboratory testing and approval, representative samples of the materials proposed to be used as backfill. On the basis of laboratory test results the Engineer shall specify the degree of compaction to be obtained in the field, which shall not be less than 90% of the maximum dry density as obtained by ASTM D-1557.

Density shall be measured in the field according to ASTM D-1556 or ASTM D-2167 by the Contractor in the presence of Engineer's representative to determine compliance with the specified degree of compaction. The cost of all laboratory and field testing shall be borne by the Contractor.

(11) **Additional Foundations**

In case other foundations are required to be installed, which are of different design than the specific types listed, the Contractor shall install these foundations as directed by the Engineer. All work performed will be in accordance with these Specifications.

(12) **Foundation Test (if required)**

The Contractor may be required to perform an uplift load test on any one footing for suspension type tower. The Engineer will designate the location and type of footing to be tested. All methods, procedures, equipment, jigs, apparatus etc., shall be subject to approval by the Engineer. No testing shall be commenced until 28 days after the final concreting nor until all backfill is placed and compacted as specified herein.

An uplift load shall be applied until a design value is reached or the footing fails. The rate of load application will be determined by the Engineer.

Payment for foundation test will be as stipulated in Bid Schedule.

4 Pile Foundations

(1) **General**

(a) **Description of Work**

The Work to be performed under these Specifications shall be carried out at the proposed site of towers after the field and laboratory test results confirmation. The Work includes, but is not limited to the following:

(i) Carrying out subsoil investigations at the tower locations through drilling, testing and sampling.

(ii) Construction of bored, cast-in-place reinforced concrete piles as shown in the Drawings.

(iii) Complete bore hole logs and record of all operations performed during the investigations and the execution of the Work.

(b) **Location of Investigation Borehole and Piles**

(i) The location of investigation boreholes and piles on the ground shall be established by the contractor in accordance with the drawings and from reference points to be provided by the Engineer. Establishing the investigation borehole and pile locations accurately in the field shall be the sole responsibility of the contractor.

(ii) The Contractor will provide the levels, survey and ground elevations for each investigation borehole and pile location. The elevations will be given with respect to permanent Bench Marks in the vicinity of the Site.

(c) **Number, Diameter and Length of Investigation Borehole and Piles**

(i) One investigation borehole, not smaller than NX size, the hole diameter approximately 75 mm shall be drilled at each location of tower where pile foundations are proposed to a depth of 25 meters from the general ground level, or 3 meters below the pile tip whichever is greater.

(ii) Bored, cast-in-place reinforced concrete piles shall be constructed having uniform diameter throughout the length as specified in the relevant drawings. Pile footings shall only be installed where the field and laboratory tests confirm the requirements. The final length of the piles shall also be confirmed after testing.

(d) **Containers**

For preserving and transporting soil and water samples collected from subsoil investigations the Contractor shall furnish jars, tubes, boxes, bags and crates, meeting the requirements as specified in these Specification. All such containers shall become the property of EMPLOYER and the cost thereof shall be included in the Contract Price.

(e) **Care and Delivery of Samples**

(i) Contractor shall be solely responsible for preserving all samples in good condition. He shall keep samples away from undue exposure to the weather, and shall keep descriptive labels and designations on sample jars and boxes clean and legible until final delivery of samples to the laboratories approved by the Engineer. The Contractor shall make arrangements for waxing of samples as directed by the Engineer.

(ii) All samples shall be submitted to the Engineer's Representative for approval before they are transported to the testing laboratory.

(iii) The Contractor shall arrange for all samples to be safely packed and careful transportation to a laboratory or to a place of storage designated by the Engineer.

(f) **Drillers and Supervisory Staff**

The Contractor shall have at Site, at all times only qualified, experienced, orderly and thoroughly competent persons including graduate engineers/geologists who shall conduct and supervise drilling operations, sampling, logging, in-situ testing and piles construction.

(2) **Execution of Piles**

(a) **General**

This clause covers all the work necessary for the execution of the bored, cast-in-place reinforced concrete piles namely:

(i) Drilling and stabilizing of bore holes for the piles.

(ii) Placing of steel reinforcement.

(iii) Mixing and placing of concrete.

The contractor shall perform all such work in accordance with requirements of this clause as well as in accordance with the methods proposed or described by him at the time of submitting his Bid and approved by the Engineer.

(b) **Method of Drilling**

The drilling of holes for piling shall be done by mud circulation or reverse rotary method or by any other method suggested by the Contractor at the time of bidding and approved by the Engineer. Regardless of the method used for drilling holes, drilling operations shall be carried out in such a way as to avoid any disturbance of the surrounding soil especially at the bottom of the hole.

(c) **Stabilizing of Holes**

There will be no permanent casing installed. Any temporary protective casing at the start of the drilling shall be later pulled out. The stabilizing of the drilled holes shall be achieved by using natural or commercial drilling mud/betonies. Permanent casing shall only be allowed with the prior approval of Engineer.

(d) **Tolerances**

Tolerances for setting out and for concrete construction shall conform to Clause 1.3 hereof. In case of piles, deviation from the vertical shall not exceed one percent on any section of the length of the holes.

(e) **Concrete**

All concrete and reinforcement placed in the construction of piles shall conform to the requirements of Clause 1.3 hereof. In addition to this, following requirements shall also be fulfilled.

(i) Promptly after cleaning of the hole to the entire satisfaction of the Engineer's Representative, concrete shall be placed in a manner that will not cause segregation of the particles or permit infiltration of water or any other occurrence which would tend to decrease the strength of the concrete or the capacity of the finished pile. Concrete placed by tremie through water shall have one extra sack of cement per cubic meter and the slump shall be limited to 150 mm maximum.

(ii) Either tremied or pumped-in concrete can be used in presence of water or of drilling mud. The method and equipment used shall be subject to the prior approval of the Engineer.

(iii) Concrete placement shall proceed without interruption until the pile is complete.

(iv) The contractor shall make three test cylinders per pile or as directed by the Engineer's Representative during the concreting of piles.

(f) **Record**

The contractor shall keep accurate logs and records of all the Work accomplished under this Contract. All such records shall be preserved in good condition by the contractor until they are delivered and accepted by the Engineer. The Engineer shall have the right to examine such records at any time prior to their delivery to him. The following information shall be included in the records for each pile.

(i) **Investigation Bore hole**

- Hole number of designation, coordinates and elevations of top of the hole.

- Type of drilling operations.

- Date and time by depths when drilling operations were performed.

- Depths at which samples were recovered and field testing was performed including complete data of field testing.

- Depth of ground water table from NSL.

- Description of subsoil conditions.

(ii) **Piles**

- A general description of sub-soil conditions and water table position at the location of the pile.

- Pile number, ground elevation of borehole and elevation of top of pile.

- Type of drilling operations.

- Date and time by depths when drilling operations were performed and piles constructed.

- Total depth of each borehole.

- Quantity of concrete and steel used for the construction of each pile.

- Quantity of constituents for each batch of mix, water cement ratio and the results of all quality control tests.

- Time of start and completion of Concrete.

- Remarks concerning any unusual occurrence during drilling and concreting of piles.

The presence of the Engineer's Representative or keeping of separate records by his representative shall not relieve the Contractor of the responsibility for the Work specified in this clause. Payment will not be made if records have not been furnished by the Contractor.

5 Tower Erection

(1) General

Contractor's work includes supply of manpower, provide construction equipment, vehicles rigging tackles for complete assembly of towers.

Profile drawing indicating the location, height and type of each tower and the construction data sheets showing the length of leg extension for each of the four legs of each tower will be submitted by contractor after final survey for approval of the Engineer.

Erection shall be done strictly in accordance with the manufacturer's drawings, material lists and approved construction data sheets.

No tower shall be erected until seven days after the last concrete was placed in the foundation, nor until backfill has been completed where and as required.

(2) **Handling**

Tower steel shall be handled so as to prevent deformation of the tower/members and damage to the galvanizing. Materials shall not be dumped, dragged, barred, rolled or dropped but shall be carefully loaded, unloaded and stored. A mechanical means such as hoist or crane shall be used when material cannot be properly handled or placed by hand.

(3) **Equipment and Methods**

All assembly and erection shall be by methods and equipment that will not cause damage to, or distort, any part of the tower/pole. Extreme care shall be taken to establish and maintain the true geometric shape of the sections of tower assembled.

Reaming shall be done only with the approval of the Engineer's Representative, and will be permitted, for the correction of undersized holes, for removing excessive galvanizing, and for holes off gauge line, to the extent that the connection cannot be made by loosening bolts in related connections. No hole shall be reamed more than one-eighth of its original diameter.

Reaming to remove fitting difficulty due to improperly set footings, to correct improper tower assembly and erection, that would distort holes or distort any member, or that would damage the galvanizing, is prohibited.

Only wrenches which properly fit the nuts and bolt heads shall be used. The use of wrenches which in any way deform the nut or cut or flake the galvanizing is prohibited. All bolts shall be entered clear to the head. All 16 mm diameter bolts shall be tightened to a torque of 10-14 kg - meters and 20 mm and 24 mm diameter bolts to a torque 17-23 kg-meters. All bolts after torqueing shall be center punched adjacent to the nut in order to prevent loosening of the nut. This method of locking the nuts will be used instead of locknuts, if locknuts are not to be provided under the specification and drawings. However, for tower type JKD locknuts are used for locking of nuts.

All nuts shall be so attached that they will be in an upward or outward position, unless such positioning is clearly impracticable.

When sections of towers are being assembled prior to erection, assembly shall be on blocking that will provide support, sufficient to prevent distortion of tower steel. If all bolts in an assembly are not inserted, at least 50 percent of the bolts in each connection shall be inserted and those bolts shall be finger-tightened only. All bolts in an assembly shall be inserted before any bolt in the assembly is fully tightened.

When erecting assembled sections of a tower, a bridle and spreader with proper points of attachment shall be used when necessary to avoid distortion or overstressing. Adequate tag lines shall be used to insure that no section of the tower being lifted will drag on the ground or against any section of the tower already erected.

At all times at least 50 percent of the bolts in each connection of erected tower members shall be inserted. Until all the bolts in the face of a section of a tower are inserted, those bolts inserted in that face during erection shall be finger- tightened only.

(4) **Correction of Mis fabricated and Damaged Steel**

All shop errors and damaged steel shall be reported to the Engineer or Engineer's Representative who will decide the manner in which corrections shall be made. All costs incurred due to punching, drilling or cutting shall be deemed to be included in the steel erection cost.

Pieces bent in handling may be used if they can be straightened to the satisfaction of the Engineer, without structurally damaging the metal. If bent pieces cannot be satisfactorily repaired, they shall be replaced.

(5) **Damage to Galvanizing**

Small areas of galvanizing damaged by abrasion, in straightening bent pieces or by necessary clipping-in the field, shall be repaired by carefully cleaning the affected area and painting. The paint will be furnished by the Contractor.

Damaged area shall be wiped with clean rags saturated with Xylene or equivalent solvent, followed by wire brushing then reclined with solvent to remove residue, and painted with one coat of "Galvanox", or approved equivalent.

Galvanizing damaged by drilling or punching shall be repaired by applying an aluminium paste or zinc rich coating material to completely fill all voids between the bolt and the surfaces bared, or all exposed steel surfaces around the holes or on cuts on which such corrective work is permitted. The coating material shall be "Galvanox" or approved equivalent.

(6) **Tower Signs and Aerial Markers**

Tower signs (danger sign, number signs and phase signs) shall normally be installed on the tower so that they will be readily visible when viewed in the direction of increasing tower numbers. However, if signs installed in the normal position will not be readily visible from a permanent access road, they shall be installed on the tower faces best exposed to view from the access roads. These signs shall be supplied by the contractor and before manufacture, a sample shall be submitted to the Engineer for approval.

(7) **Anti-climbing Devices**

An anti-climbing device will be installed on each tower as shown on the relevant drawings. The anti-climbing device normally will not be installed until all the tower and wire stringing work is complete.

The tower steel will be provided with holes for mounting the anti-climbing device brackets. The brackets shall be fabricated from mild steel and shall be galvanized in accordance with ASTM A153. The brackets along with barbed wire shall be supplied by the contractor. Any holes required to be punched/drilled for installation of Anti-climbing Devices shall be carried out by the Contractor without any extra cost.
After erection, tower shall be cleaned of any foreign matter.

(8) **Anti-Bird Devices**

All poles shall have detachable anti-bird devices, over each suspension/jumper insulator string. These anti-bird devices shall be spike type and galvanized and can be fixed on cross-arms by use of bolts and nuts.

6 Installation of Insulators and Hardware

Insulators and insulator hardware shall be assembled and installed as shown on the drawings and in accordance with the recommendations of the Manufacturers.

No insulator with chips or cracks in the porcelain or defects in the fittings shall be installed.

Uncrated or otherwise unsupported strings of insulators shall not be picked up or suspended except by the upper units of the string. All cotter pins installed by the Manufacturer shall be checked.

All insulators shall be cleaned with a clean cloth when installed. The porcelain shall be bright and all other parts free from dirt. Only clean rags free from any abrasive material shall be used for cleaning insulators.

Wire brushes shall not be used for the cleaning of any parts, metal or otherwise. The use of solvents will not be permitted.

Each completed suspension assembly shall be adjusted to hang in a vertical plane through the axis of the tower. Where possible nuts locknuts and cotter pins shall be placed to face the tower body.

Workmen shall not climb on insulators during stringing operations or at any other time.

When raising conductor strain assemblies the insulators shall be kept under tension to avoid possibility of those being damaged due to excessive bending.

A wastage allowance of 0.5% for insulators will be entertained.

7 Stringing Conductor and Overhead Shield Wire

(1) **General**

The conductor and overhead shield wire shall be strung on double circuit towers as single & twin conductor bundle per phase.

(2) **Safety Grounding**

It shall be the Contractor's responsibility to take adequate safety precautions to protect his employees and others from the potential voltage build-up during construction. The following minimum safety and grounding procedures shall be followed by the Contractor during stringing operations in the Sections with parallel existing high voltage lines.

The voltage build-up may be comparatively small during normal operations, but could be lethal during switching and ground fault conditions on the energized parallel line.

Temporary electrical grounds shall be placed at both ends of the section requiring special safety precautions and at intervals along the line which is under construction. The grounding sets installed at both ends of the section of line shall remain in place until the completion of the work and shall be removed as the last phase of cleanup. Hot stick shall be used for installing and removing the grounding sets.

All temporary grounds furnished and installed for protection shall be clearly visible for inspection and shall be flagged by use of a red cloth placed at the point of grounding. All grounds, except those placed at both ends of the section, and red flags shall be removed when they are no longer needed for protection.

All pulling and tensioning equipment shall be bonded and effectively grounded with approved-type driven grounds securely attached to the equipment. At least two driven grounds shall be used at both the pulling and tensioning set up. All conductive parts of the tensioning set up and equipment shall be operated from grounded or insulated platform provided with barricades or insulated walkways.

Running grounds shall be installed within 6 meters of the tensioning set up to constantly ground each sub- conductor and overhead shield wire. At the pulling set up grounding shall be achieved by the use of block grounds connected to the adjacent tower by approved type ground leads bonded to the tower with approved type clamps. These connections shall be removed by the use of a hot-stick.

An approved-type driven ground shall be located at each side and within 3 meters of working areas where conductors or overhead shield wires are being compressed/terminated to dead-end assemblies or spliced at ground level. The two ends to be spliced shall be effectively bonded together prior to and during splicing operation. Splicing and compression/termination operations at dead-end assemblies shall be carried out on either an insulated platform or on a conductive metallic grounding mat roped off with an insulated walkway provided for access to the mat.

Installation and removal of temporary jumpers, at any time the conductor is not continuous, shall be performed by hot stick methods.

All conductors and overhead shield wires shall be bonded to the tower with approved-type tower grounds at any isolated tower where it may be necessary to complete work. Work on dead-end towers shall require grounding on both sides of the tower. Grounds may be removed when the work is completed, providing the line is not left open circuited at an isolated tower at which work is being completed.

For all sections of the line under work, which are not in parallel with energized high voltage lines or otherwise required special safety precautions, only the provision of the grounding at the pulling and tensioning stations shall be required.

All herein specified provisions shall not prevent installing as many additional grounds as deemed necessary for the protection of workmen against static and accidental contacts with foreign circuits.

Clipping crews and all others working on the conductive pulling lines, isolated conductors, or overhead shield wires shall be protected by individual hot stick clamp type grounds installed at every work location.

(3) **Approved Type Grounding Material**

Approved type moving grounds shall be such as to exert constant pressure on the conductor or overhead shield wire, and the contact rollers shall be with permanently lubricated-type bearings.

Approved-type driven ground rods shall be minimum of 16 mm diameter copper weld or equivalent. Ground rods shall be driven into the ground a minimum of 2.5 meters.

Approved-type tower grounds shall be hot stick clamp grounds, bonded to the tower with a flexible ground lead.

Approved-type ground leads shall be at least 43 mm^2 cross-section copper or equivalent.

Approved-type insulated platforms shall be constructed of 65 mm nominal dimension lumber supported on 102 mm nominal dimension sills, or of materials of equivalent insulation.

At the tensioning set up, the insulated platform and rope barriers shall extend completely around the equipment set up in such a manner as to prevent any one standing on the ground from contacting any conductive part of the equipment.

(4) **General Safety Precautions**

Prior to initiation of the stringing in any section of the line the following shall be insured.

(a) The installation of all towers within the section of the line is satisfactorily completed.
(b) The stringing loads will not exceed the design loads for any of the towers.
(c) If any tower is to be subjected to loads exceeding the design loads, the Contractor shall provide temporary bracing for such tower, and the bracing is subject to approval by the Engineer.
(d) The stringing and sagging operation is such that no sudden loads will be applied on the towers.

(5) **Safety Precautions at Crossings**

Wherever any power line, communication line, highway or railroad is to be crossed, the owners shall be notified 30 days in advance and all temporary changes shall be pre-arranged.

The Contractor shall not erect towers near, nor string conductors or overhead shield wires over, energized power circuits until a Hot-Line Order is placed on the energized line i.e., until “Permit to Work” has been arranged from relevant quarters.

Qualified personnel shall remain at the site of work while the Hot-Line Order (Permit to Work) is in effect and shall ascertain that all personnel are in the clear and properly notified before the Hot-Line Order is released.

All existing lines which are de-energized for crossing shall be short-circuited and grounded at each side of the crossing.

Guard structures shall be provided at all crossings, as required for the protection of the conductor, line, road, structure, or feature being crossed, and as required by the owner, or EMPLOYER.

Guard structures shall be of sufficient strength and stability to withstand the stresses to which they may be subjected.

As soon as a guard structure has served its purpose, it shall be removed and all holes shall be backfilled.

(6) **Atmospheric Adverse Conditions**

All pulling and stringing operations shall cease when either wind velocities are such as to cause conductors to deflect more than 1.5 meters at midspan from the normal no wind position or there is any indication of lightning activity in the area.

(7) **Handling and Stringing of Conductors**

The conductor will be furnished in matched sets of twelve reels for twin bundle conductor double circuit line & six reels for single conductor double circuit line and shall be strung by the controlled tension method. At no time will the conductor be allowed to contact the ground or any object which might cause damage to the conductor. All reels shall be inspected in the field prior to installation. Reels showing signs of careless or unusually rough handling, such as split frames or crashed outer protective lagging shall be inspected carefully for conductor damage.

Preparatory to unreeling a conductor from the reel, the outer protective lagging shall be removed carefully, and all surfaces in contact with the running conductor shall be examined for protruding objects which might damage the conductor.
Care shall be taken to insure that no dirt is carried by the conductors from the reels. Reels shall be properly cleaned before starting stringing operation of any line section.

A spreader bar shall be used when lifting or lowering the reels. Full or partial reels shall not be dropped or rolled under any circumstances.

The two conductors in a bundle shall be strung simultaneously and shall hang in stringing blocks for the same period of time not exceeding 24 hours and, in exceptional cases, up to 48 hours before being sagged to the specified sag.

The two conductors shall start and end approximately at the same points of the line and stringing operations shall be planned to keep waste to a minimum. Lengths of conductor less than 100 meters are scrap lengths and shall not be spliced into the line without the approval of the Engineer. Jumpers shall be cut only from scrap lengths unless otherwise permitted.

Stringing sheaves may be hung on the insulator strings or in straps of equal length attached to the structure arms with suitable hooks or clamps. The sheave shall support the conductors at the same elevation as when clipped in.

Stringing of conductors and temporary guying of conductors shall be done by methods that will prevent damage to the conductor and structures in any way. Temporary guying/dead-ending to tower footings will not be permitted. Where temporary dead-end is required, the conductors shall be attached to suitable temporary anchors.

The general requirements for installation of the temporary anchors are as follows:

The angle formed by conductors and shield wires to the horizontal shall not exceed 15 degrees.

The anchors shall be aligned in the direction of stringing:

The anchors and their accessories shall withstand the maximum conductor tensions with a factor of safety of three.

Two sub-conductors of one phase shall be strung simultaneously by means of running board attached to a single pulling line with a swivel. Sub-conductors shall be connected to the running boards with a swivel connection and a stocking-type grip. The grips shall be secured to the conductor by means of a band installed around the tail end of the grip.

Following stringing, measures shall be taken to prevent the sub-conductors of the bundle from contacting each other. Before adjusting the sag of the conductors, sub-conductor slapping may be prevented by pulling each of them to different sag which will separate them at least 150 mm vertically from either of the other sub-conductor at midspan. After adjusting the sag, the following conditions will require sub-conductors tie-off: any time that sub-conductors slapping is noted, any time that prior to spacer installation the conductors are left unattended.

Two reel lengths of conductor may be pulled into the sheaves using only approved swivels and grips to make the connections between reel lengths. Double socking will be permitted, but permanent splices shall not be pulled through a sheave or bull-wheel.
All sheaves, swivels and grips shall be inspected daily for free and easy movements and to assure that such may be safely used. Sheaves carrying pulling lines shall not be used for conductors.

The conductor shall be kept clean by removing grease, dust or any other contamination. Cleaning shall be done immediately after the conductors leave the tensioning device. The method of cleaning shall be wiping with a clean cloth saturated with proper cleaning agent. When it is necessary to slack the conductor at any time during the stringing operation, it shall be done with the approval of the Engineer's Representative. Rigid plank guard or lagging, or a combination of both shall be used to prevent damage. Lagging shall consist of nonmetallic material which will not damage the conductor and shall be rigid so that it will not be displaced by the motion of the conductor. It shall be free of any material, which can be transferred to the conductor.

Sections of the conductor damaged by application of gripping attachments or any other way during stringing shall be removed before the conductor is sagged in place. The conductor repairs shall be done as outlined in these specifications.

All stringing operation must be conducted so that at no time will any suspension structure be subjected to longitudinal loads and at no time will any tension structure except dead-end structure be subjected to excessive unbalanced loads resulting from longitudinal loads on opposing faces. At no time shall any structure be subjected to torsion. The vertical angles of pulling lines shall be such as to minimize the vertical loading on towers. The attachment of temporary guys and stringing equipment on towers shall be done only with approval of the Engineer.

The conductor and shield wire reels, tensioners, and pulling machines shall be located as near to midspan as possible but in no case shall the slope of the shield wire or conductor between any machine and the stringing block or any anchor lead be steeper than three horizontal to one vertical (15°-20° to the horizontal).

The tension in the conductor during stringing shall be maintained as constant as practicable. The sag in each conductor must be maintained at least 20 percent greater than the sagging value specified in sag charts and the maximum pulling tension shall never exceed the sagging tensions.

If the conductor is left unattended, during stringing operations, it shall be freely suspended between stringing sheaves so as to provide a safe clear distance over ground or obstructions.

The minimum tension shall be such as to maintain the conductors at a minimum distance of 3 meters above ground or any obstacle.

When there is possibility of conductor being damaged due to wind or other conditions they shall immediately be fully tensioned. It is recommended that variations in stringing tensions be as small as possible and the tension shall be near the maximum permitted. Immediately after completing stringing of a section of the line, the tensions shall be increased to the maximum permitted stringing values.

The spinning of the conductors and shield wires shall be prevented during stringing. Unreeling of the conductors shall be closely watched at all times in order to detect any damage or flaw in the conductor.

(8) **Handling and Stringing of Shield Wires/OPGW**

One 9.0 mm dia. 7 strand galvanized Overhead Shield Wire/OPGW (as required) shall be strung for the entire length either before or at the same time the conductors are strung.

The specifications used for handling and stringing the Overhead Shield Wire shall be the same as for the conductors. However, the contractor shall submit his proposal regarding specifications to be used for handling and stringing of OPGW and wrapping of Fiber Optic Cable on Shield wire of the existing transmission line which shall be followed after approval by the Engineer.

(9) **Conductor Sagging**

After being pulled into the sheaves all sub-conductors in a sag section shall be sagged within 24 hours.

The conductors shall be sagged in accordance with sag charts, furnished by the Engineer. The exact value of sag for a given span length at a given temperature can be ascertained from the appropriate table or by linear interpolation of data.

Conductor sagging temperature shall be measured by an accurate thermometer. A length of core shall be pulled from a 0.5 meter length of the conductor sufficient for thermometer to be inserted into the space vacated by the core.

The length of conductor shall be placed in the full sun at least 4 meters above the ground for a minimum period of 15 minutes. A thermometer in a container which stimulates the effect of the conductor may also be used.

The length of conductor sagged in one operation shall be limited to the length that can be sagged satisfactorily, usually 4,000 meters to 8,000 meters.

Temporary snubs shall be used between a section previously sagged and clipped in and the section being sagged. Dead ending or snubbing will not be permitted on any tower except dead end towers at the normal point of attachment.

When conductors are sagged a mark shall be placed on each conductor at the last structure in each pull. The location of this mark shall be checked after the succeeding sag has been made to ascertain whether or not the back spans are still sagged properly. The wire grips may be removed only after the next section of the line has been sagged.

When sagging conductor lengths of more than four spans, the sag shall be checked near each end span and at or near the middle span of the length being sagged. The length of the spans used for checking sag shall be as nearly equal to the ruling span as practicable.

The sag of each span more than 600 meters in length shall be checked in addition to above. Sag at sharp vertical angles and horizontal angles of 10 or more degrees shall also be checked on both sides of the angle.

The sags shall be determined by means of a transit or other approved methods. At least one person shall be provided to measure the correct sag for pulls up to five spans, two persons for six to ten spans and three persons for eleven spans or more.

The total number of spans to be checked shall be not less than two in a four-span section, three for a section up to two kilometers and in proportion for a longer section.
In the twin conductor bundle the sag of the two sub-conductors shall be the same.

A tolerance of plus or minus 10 mm of sag per 30 meters of horizontal span length, but not to exceed 150 mm in any one span, will be permitted, provided; the conductor tension between successive sagging operations is equalized so that the suspension insulator assemblies will assume the proper position when the conductor is clipped in.
Log books shall be maintained to record all conductor installation data and chronological progress.

The temperature, spans, tower, general weather, wind velocity and direction, sags, tensions, and drawing references shall be recorded for each section of conductor as it is being installed, tensioned and sagged. When possible, sagging operations shall be scheduled when wind velocity is at or near zero.

Radio or telephone communication shall be used to relay information and instructions between the conductor payout station, intermediate check points, mobile stations and the pulling stations at all times during stringing operations. A failure of communication requires immediate cessation of the conductor pulling operation.

A wastage allowance of 1% for sag and jumper in conductor and OPGW will be entertained.

(10) **Conductor Clipping-in**

After being sagged, the conductor shall be allowed to hang in the stringing blocks for not less than 2 hours before clipping-in is commenced, to permit the conductor tension to equalize.

Plumb marks shall be made on the conductors in the vertical plane through the center line of the tower prior to clipping-in. Only paint, crayon, or wax pencil shall be used for marks on conductors.

All conductors marking in the section being sagged shall be accomplished while the conductors are in the sheaves and before clipping-in or dead ending is begun.

The total time during which the conductor is allowed to remain in the stringing blocks before being clipped-in shall not exceed 72 hours.

Torque wrenches shall be used to tighten all nuts on clamps. The torque applied shall be in conformance with the recommendation of the manufacturer.

Yoke plates for twin bundle insulator strings shall be installed as shown on the drawings and shall hang at 90 degrees to the conductor axis within a tolerance of plus or minus 2.5 cm.

Well-padded pull-lift hooks or other approved methods shall be used for handling conductors during the clipping-in operation.

(11) **Installation of Conductor and Shield Wire/OPGW Accessories**

(a) **Splices and Dead Ends**

All splices shall be of the compression type.

All splices shall be made at least 15 meters away from structures and no splices shall be made in dead-end spans or spans greater than 600 meters or spans crossing over the highways, railroads, major canals, rivers and transmission lines of voltages greater than 35 kV unless approved by the Engineer.

As a rule not more than one joint or splice should be made in any one conductor in any one span. However, in exceptional cases, as in the repair of damaged conductors, or when necessary owing to stringing limitations two splices will be allowed.

The splices and compression dead ends shall be installed in accordance with the recommendations of the Manufacturer of the accessories.

Conductor shall be laid out straight for a distance of 15 meters and straightened at the end before preparation of the ends for splicing or dead-ending. The ends of the conductor shall be thoroughly cleaned immediately prior to compressing. After the compression has been completed, all corners, sharp projections and indentations shall be carefully rounded and smoothed, and tape, tape residue, and filler paste shall be removed from splice and conductor. If the completed splice requires straightening, it shall be straightened on a wood block by use of a wooden maul.

Splicing, dead-ending and repair of damaged conductor shall be done in the presence of the Engineer's representative.
If the completed splice or dead-end is not satisfactory, in the opinion of the Engineer, or Engineer's representative, it shall be removed and a new splice or dead-end shall be properly installed.

The Contractor's inspector shall stamp his own initials on the aluminum sleeve of each compression joint and compression dead-end completed under his supervision.

(b) **Repair of Conductors & Shield Wire/OPGW**

Damage is any deformity on the surface of the conductor or shield wire/OPGW which can be detected by eye or by feel and shall be repaired by whichever the following methods is appropriate:

(i) Repair by manual polishing
(ii) Installation of repair sleeves over the damaged part
(iii) Installation of compression joints
(iv) Replacement with new conductor or shield wire/OPGW

Slight damage such as superficial scratches or abrasions, which are not deeper than one-third the strand diameter, can be repaired by dressing with a fine emery cloth.

Severe cuts which cannot be repaired with emery cloth due to their depth or extension, and cause increase in the resistance of the external layers, shall be repaired by use of repair sleeves, provided that not more than one-third of the outer layer is cut or damaged over a length of less than 10 centimeters.

Damages of extent greater than described in above paragraphs shall be repaired by replacing the damaged length of the cable using compression joints.

When there is repeated damage in the same span or in consecutive spans, the Engineer/Engineer's Representative may require all conductors in these spans to be replaced.

In the case when signs of corrosion are detected during the stringing operation, the reels containing corroded conductors shall be set aside, the operation shall be interrupted and the Engineer's Representative shall be informed immediately.

Whenever a repair sleeve is installed, a rope cage shall be placed on the sleeve to ensure that there will be no damage from sub-conductor slapping prior to installation of the spacer- dampers.

For the repair of the shield wires, only compression joints shall be used.

(c) **Jumper Connections**

Where compression type dead-ends are used, the jumper shall be one continuous piece, and compression-type jumper terminals bolted to the compression-type dead-ends shall be used.

At conductor and overhead shield wire dead-ends with bolted strain clamps, sufficient length of wire to form the jumper loop to clear the tower shall be allowed. Parallel groove bolted clamps will be used for connection.

8 Installation of Dampers

(1) **Vibration Dampers**

Vibration dampers shall be attached to the conductor in case of single conductor per phase arrangement and overhead shield wire/OPGW at the ends of all spans and as designated on the data sheets. The vibration dampers shall be fastened securely to conductor and overhead shield wires/OPGW so that they will hang in vertical planes. Spacing of dampers shall be in accordance with the drawings.

Breakaway type bolts shall be tightened until the outer head breaks off.

9 Pre Commissioning and Commissioning Tests

A. Pre Commissioning Tests

(a) Mechanical Tests

1. For steel structures, ensure that structure type is as per specification/ drawings/ structure list.
2. Check galvanizing and thickness (rust is not acceptable).
3. Check bolt types and tightness (torque wrench method).
4. Ensure anti-climbing guards are correctly installed.
5. Check step bolt tightness.
6. For porcelain insulators, check insulators for chips, cracks, etc. Ensure correct number of insulators have been installed in each string. Ensure that cotter keys have been properly installed.
7. Make sure that insulators are clean and line is safe to be energized.
8. Check that all line hardware (insulators, corona rings, vibration dampers, spacers, conductor clamps, armor rods, etc.) is installed correctly and in correct locations as per specifications and drawings.
9. Check that all splices are correct and installed in correct span locations.
10. Check that all jumpers are installed correctly. Ensure correct clearances between jumper and structure as well as with other phases at acute angle locations.
11. Ensure there is no twist in the insulator string.
12. Check that overhead shield wire and OPGW are grounded to towers as specified.
13. Ensure that sags for phase and overhead ground conductors are even and according to the specification.

14. Check that ground clearances are as per specification.
15. Check circuit/phase identification plates, structure number plates, danger sign plates, etc. have been correctly installed at each structure and aerial markers at the required structures.
16. Check line/phase correctly transposed at the specified locations and clearance between the phases is as per specification.

(b) Electrical Tests

1. Check tower footing resistance as per specification.
2. Verification of physical phase arrangement.
3. Perform sequence impedance test (both zero and positive sequence).
4. Perform continuity and insulation test of complete transmission line with appropriate test equipment.

B. Commissioning Tests

1. Perform phase sequence/rotation check.
2. Inspection of facilities for any visual/audible abnormality.

SECTION-05

SPECIFICATION P-117:88
(UDC 621.315.5:669)

ALUMINIUM ALLOY STRANDED CONDUCTOR

PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY DESIGN
DEPARTMENT (T&G) POWER

SPECIFICATION P-117:88

ALUMINIUM ALLOY STRANDED CONDUCTDOR

AMENDMENT NO.1 DATED 12TH FEBRUARY,1990

1. CLAUSE 3.1

   Please add the sentence " The maximum value permitted is 0.0328 ohm. Mm2/m at 20ºC" at the end of this clause.

2. CLAUSE 3.4

   i) Please add the word "a" at the end of the heading of this clause.
   ii) Please add the word "a" after the words " coefficient of resistance," in the second line of this clause.

3. CLAUSE 5.5.4.1

   Please replace the work "sample" in 3rd line with "sample".

4. Clause 6.4.1

   i) Please replace the formula for resistance at 20ºC (R20) as under:-

   $$R20 = RT \left(\frac{1}{1+ a\,(T-20)} \right)$$

   ii) In the second last line of this clause, please write the word "a" in the blank space which is after the word "and" & on the left side of the sign of equality.

   iii) Please replace " (= 0.003 60)" with " (= 0.00360)" in the last line of this clause after the words " of resistance".

5. Clause 9.5

   Please replace the word "not" in 3rd line with "no".

6. Clause 10.1

   i) Please replace the word " rigors" in 4th line with "rigours".
   ii) Please add the sentence "The reels should be suitable for tension stringing and capable to withstand its rigours" after 2nd sentence in the fifth line of this clause.
   iii) Please replace the word " entachlorophenol" in 3rd last line of this clause with " pentachlorophenol".

7. Fig 1, REEL DIMENSIONS

i) Please replace the value “2200” for Nominal length of Cairo Conductor with “2220” in table of fig 1.

ii) Please replace the value “ 4598” with “4593” for Nominal weight of Greely Conductor in the table of fig 1.

C O N T E N T S

PRINTING HISTORY

First approved on 15th July, 1979.

First revised on April, 1988.

Amendment No. 1 Dated 12th February, 1990.

SPECIFICATION P-117: 88

(UDC 621.315.5:669)

ALUMINIUM ALLOY STRANDED CONDUCTORS

0 FOREWORD

This standard specification has been prepared by the Design Department Power Wing , WAPDA and lays down specifications for Aluminum Alloy Stranded Conductors.

This specification is based on I.E.C. 208 and ASTM B399 and is subject to revision as and when required.

This specification is intended for procurement of material and does not include provisions of contract.

1 SCOPE

This specification covers concentric layers stranded conductors, made from round aluminum alloy wires, for use as overhead conductors in polluted area.

2 DEFINITIONS

For the purpose of this specification the following definitions shall apply.

Stranded Conductor

Conductor consisting of seven or more aluminum alloy wires of the same nominal diameter twisted together in concentric layers. When the conductor consists of more than one layer, successive layers are twisted in opposite directions.

Diameter

Mean of two measurements at right angles taken at the same cross- section.

Direction of Lay

The direction of lay is defined as right-hand or left-hand. With right hand lay, the wire conform to the direction of the central part of the letter “Z” when the conductor is held vertically. With left-hand lay, the wires conform to the direction of the central part of the letters “S” when the conductor is held vertically.

Lay Ratio

Ratio of the axial length of a complete turn of the helix formed by an individual wire in a stranded conductor to the external diameter of the helix.

Heat – Treatment Batch

Furnace load of material heat-treated at the same time, at the same temperature and for the same length of time.

3 STANDARDS FOR ALUMINIUM ALLOY WIRES

Resistivity

For the purposes of this specification, the standard value of resistivity of aluminum alloy wire which shall be used for calculation is to be taken as 0.0325 ohm. mm2/m at 20º C.

Density

At a temperature of 20º C the density of aluminum alloy wire is to be taken as 2.70 kg/dm3.

Coefficient of Linear Expansion

The Coefficient of linear expansion of aluminum alloy wire is to be taken as 23x10-6 per centigrade degree.

Constant – mass Temperature Coefficient

At a temperature of 20º C the " Constant-mass" temperature coefficient of resistance, of aluminum alloy wire measured between two potential points rigidly fixed to the wire, is taken as 0.00360 per centigrade degree.

4 Material – (6201 Aluminum Alloy)

The conductor shall be constructed of heat – treated aluminum- magnesium-silicon alloy wires containing approximately 0.5% magnesium and approximately 0.5% silicon and having the mechanical and electrical properties specified herein.

The wires shall be smooth and free from all imperfections not consistent with good commercial practice.

The ultimate tensile stress of wire before or after stranding shall not be les than 30 kg/mm².

5 DIMENSIONS AND CHARCTERISTICS

Standard Sizes

The dimensions and characteristics of the conductor standardized for use by WAPDA and covered by this specification are given in Table-I.

TABLE- I

DIMENSIION AND CHARACTERISTICS OF ALUMINIUM ALLOY CONDUCTORS

Code Word	Stranding and wire dia	Dia of complete conductor	Calculated area of complete conductor	Rated ultimate strength	D. C. resistance at 20ºC	Weight
	no/mm	mm	mm²	kg	Ohms/km	Kg/km
Almond	7/2.34	7.02	30.10	903	1.094	82
Azoza	7/3.37	10.11	62.44	1873	0.527	171
Alliance	7/4.77	14.31	125.09	3753	0.263	342
Cairo	19/3.98	19.90	236.38	7091	0.140	650
Greeley	37/4.02	28.14	469.80	13835	0.071	1295

Tolerance on Nominal Diameters of Wires

The aluminum alloy wires shall not depart from the nominate diameter by more than the following amounts.

Nominal Diameter	Tolerance
2.50mm& greater Less than 2.50mm	+- 1% +-0.025mm

5.3 **Joints in Wires**

5.3.1 **Conductors Containing Seven Wires**

There shall be no joints in any wires of a stranded conductor containing seven wires, except those made in the base rod or wire before final drawing.

5.3.1 **Conductors Containing more than Seven Wires**

In stranded conductors containing more than seven wires, joints in individual wires are permitted in any layer except the outermost layer (in addition to those made in the base rod or wire before final drawing) but no two such joints shall be less than 15 m apart in the complete stranded conductor. Such joints shall be made by resistance butt-welding and shall, subsequent to welding, be annealed over a distance of at least 200 mm on each side of the joint. They are not required to fulfill the mechanical requirements for un-jointed wires.

5.4 **Stranding**

5.4.1 The wires used in the construction of a stranded conductor shall, before stranding, satisfy all the relevant requirements of this specification.

5.4.2 The lay ration of the different layers shall be within the limits given in Table-II.

TABLE-II

Lay ration for aluminum alloy stranded conductors.

Lay Ratio						
No. of wires in conductor	6 wire Min.	Layer Max.	12-wire Min.	Layer Max.	18-wire Min.	Layer Max.
7	10	14	-	-	-	-
19	10	16	10	14	-	-
37	10	17	10	16	10	14

5.4.3 In all constructions, the successive layers shall have opposite directions of lay, the outermost layer being right-handed. The wires in each layer shall be evenly and closely stranded.

5.4.4 In aluminum alloy stranded conductors having multiple layers of wires, the lay ration of any layer shall be not greater than the lay ration of the layer immediately beneath it.

5.5 **Calculation of Conductor Properties**

5.5.1 The properties of the conductors have been calculated in accordance with clauses 5.5.2 through 5.5.4.

5.5.2 **Increase in Length due to Stranding**

When straightened out, each wire in any particular layer of a stranded conductor, except the central wire, is longer than the stranded conductor by an amount depending on the mean lay ration of that layer.

5.5.3 **Resistance and Weight of Conductor**

The resistance of any length of a stranded conductor is the resistance of the same length of any one wire multiplied by a constant, as given in Table-III.

The weight of each wire in any particular layer of a length of stranded conductor, except the central wire will be greater than that of an equal length of straight wire by an amount depending on the mean lay ratio of that layer (see 5.5.2 above). The total weight of any length of stranded conductor is, therefore, obtained by multiplying the weight of an equal length of straight wire by constant, as set out in Table-III.

TABLE – III

STRANDING CONSTANTS

Number of wires in Conductor	Stranding Constant	
	Weight	Resistance
7	7.091	0.1447
19	19.34	0.05357
37	37.74	0.02757

5.5.4 **Strength of Conductor**

The strength of a stranded conductor, in terms of the strengths of the individual component wires, may be taken to be 95% of the sum of t he strength of the individual wires calculated from the value of the minimum ultimate tensile stress given in Sub-Clause 4.3.

5.5.4.1 For testing the ultimate strength of a complete stranded conductor, suitable fittings shall be applied to the ends of a sample of conductor which shall b e not less than 5m long and the assembly shall then be pulled in a suitable tensile testing machine. When so tested, the conductor shall withstand at least 95% of its strength calculated as indicated above.

6 TEST METHODS

6.1 Tensile Test

6.1.1 This test shall be made on aluminum alloy wires prior to and after stranding. The breaking load of the specimen cut from the sample shall be determined by means of a tensile testing machine of which the accuracy can easily be checked and to which adjustments can be made if necessary.

6.1.2 When automatic tensile testing machine is used, the load shall b e applied gradually and the rate of separation of jaws of the testing machine shall not be grater than 100mm per minute.

6.1.3 When a hand operated lever testing machine is used, 90% of the specified breaking load shall be applied quickly and the load shall then be increased steadily until the specimen breaks. The time taken in applying the last 10 percent of the load shall be approximately 15 seconds and the total time from first application of load to fracture shall be approximately 20 seconds.

6.1.4 When tested before and after stranding, the ultimate tensile strength shall be not less than 30 kg/mm^2.

6.2 Elongation Test

6.2.1 The englogation of a specimen tested as per clause 6.1 shall be determined as follows:

The specimen shall be straightened by hand and an original gauge length of 200mm shall be marked on the wire. A tensile load shall be applied as described in clause 6.1 above and the elongation shall be measured after the fractured ends have been fitted together. If the fractured ends have been -------------------. If the fracture occurs outside the gauge ------, or within 25mm of either marks, and the required elongation it not obtained, the test shall be disregarded and another test made.

When tested before or after stringing, the elongation shall be not less than 4% on a gauge length of 200mm.

6.3 **Wrapping Test**

6.3.1 The aluminum alloy wire shall be wrapped round a mandrel of diameter equal to the wire diameter to form a close helix of eight turns. Six turns shall then be unwrapped and again closely wrapped

6.3.2 The wire shall not break or show any cracks

6.4 **Resistivity Test**

6.4.1 The electrical resistance of aluminum alloy wire shall be minimum to an accuracy of at least one part in a thousand. The length of the specimen shall be sufficient to give the accuracy required and shall be suitable for the method of the testing used.

The electrical resistance of one specimen cut from each of the samples taken form not loss than 10% of the individual lengths of aluminum alloy wire included in any one heat-treatment batch which will be included in any one consignment of stranded conductor, shall be measured at a temperature which shall be not less than 10°C and not more than 30°C. The measured resistance shall be corrected to the value at 20° C by means of formula:

$$R_{20} = R_T \left(\frac{1}{1+ (T-20)} \right)$$

Where: T = Temperature of measurement in °C

R_T = resistance at T°C

R_{20} = resistance at 20°C

and = constant-mass temperature coefficient of resistance (= 0.003 60)

6.4.2 The resistivity at 20°C shall then be calculated from the resistance at 20°C. The resistivity at 20°C shall not exceed 0.0328 ohm. mm^2/m.

7 TESTS BY MANUFACTURER

7.1 The manufacturer shall progressively carry out tests to maintain quality control and to ensure manufacturer of conductor in compliance with the specification. Such test shall include the following, but need not be restricted to them.

1) Visual inspection
2) Verification of Dimensions
3) Tensile and Elongation Tests
4) Wrapping Tests
5) Resistivity Tests

7.2 Visual inspection and verification of dimensions shall be carried out as routine tests on wires and complete conductors.

7.3 Before the start of manufacture the base rod shall be tested for resistivity. One specimen shall be selected at random out of every 10% of the length of aluminum alloy wire included in any one consignment for test. Material not conforming to the stranded shall not be used.

7.4 The tensile strength and elongation tests shall be carried out on wire finished to size but before stranding. Samples shall be drawn from not less than 10 percent of the individual lengths of aluminum alloy wire which will be included in any one consignment.

7.5 The manufacturer shall maintain a record of all the tests carried out by him for examination by the authorized representative of WAPDA.

7.6 The manufacturer shall furnish a certificate to the effect that the aluminum alloy stranded conductor manufactured by him conforms in all respects to the requirements of this standard.

8 ACCEPTANCE TESTS

8.1 The following tests shall be carried out on the aluminum alloy stranded conductor for acceptance.

1) Visual Inspection
2) Verification of Dimensions
3) Tensile and Elongation Tests
4) Wrapping Tests
5) Resistivity Tests

9 ACCE[TAMCE AND REJECTION

9.1 The manufacturer shall divide each consignment into lots for inspection. These lots shall be so selected that material in a lot is of reasonably uniform quality and as far as possible, is manufactured at the same time and under the same conditions. The manufacturer shall keep sufficient production records to ensure that this can be done regularly. A lot may contain any number of lengths upto a maximum of 150.

9.2 From each lot, regardless of its size, samples of wires shall be taken at random form approximately 10% lengths of stranded conductor included in any one consignment. One sample sufficient to provide one specimen for each tests, shall be taken from each strand of the conductor in each of the selected lengths.

9.3 The samples taken shall be subjected to each of the tests prescribed in clause 8. The lot shall be accepted, if for each test, the sample complies with the requirements of clauses 9.4 and 9.5.

9.4 If in any test three or more specimens fail, the entire lot shall b e rejected.

9.5 If two specimens fail in any tests, a further sample in accordance with clause 9.2, shall be taken from the lot, and the particular tests repeated. If there are not further failures the sample shall be considered acceptable for the test.

9.6 If in any test three or more specimens fail, the entire lot shall be rejected.

9.7 The manufacturer shall afford to the inspector all necessary test facilities and assistance for carrying out the tests. The facilities shall be provided free of charge.

10 PACKING AND MARKING

10.1 Aluminum alloy stranded conductor shall be supplied on stranded wooden reels as per fig.1. The reels shall be made from high quality wood and shall be of sound construction, able to withstand the usual rigors of transportation and field construction. The complete periphery of the reels apart from being protected by heavy wooden lagging railed at each end of the reel flanges as per fig. 1 shall also be bound by two steel straps. The wooden reels shall be given two brush coats of 5 percent entachlorophennol solution in oil before winding of conductor .The conductor shall be wound tightly

10.2 The conductor shall be supplied in lengths specified in fig 1. Each reel shall contain either one or two lengths only as specified. A tolerance of plus or minus 5 percent is permitted on the conductor length. Additionally it shall be permissible to supply not more than 5 percent of the lengths on any one order in random lengths, none of which shall be shorter than one third of the nominal length.

10.3 The manufacturer shall provide the following markings on the reels in legible and indelible letters.

1) Manufacturer's name and designation
2) Conductor designation
3) Address of the consignee and purchase order number
4) Serial number of the reel

10.4 The manufacturer shall stamp the following information on metallic plates which shall be securely nailed to the reel

1) Size and designation of aluminum alloy stranded conductor
2) Net weight, tare weight and gross weight, in kg.

3) Total length of the conductor on the reel, in meters
4) Serial number of the reel.

10.5 Both sides of the reel shall have an arrow marking indicating the direction of rolling.

10.6 All marking shall appear on both sides of the reel in the position indicated in figure 1.

Encls: Figure 1.

Conductor	**Reel Designation**	**Flange Dial L mm**	**Flange Thickness P mm**	**Drum Dia. M mm**	**Inside Width N mm**	**Arbor Hole Q mm**	**Lagging Thickness O mm**	**Nominal Length Meters**	**Nominal Weight of Conductor kg**
Almond	NR910	910	40	450	560	70	50	2X1700	279
Azoza	NR1070	1070	60	530	700	70	50	2X1600	547
Alliance	NR1017	1070	60	530	700	70	50	1600	547
Cairo	NR1680	1680	75	970	800	70	50	2200	1443
Greeley	NR2200	2200	95	066	1150	125	50	3547	4598

FIG 1. REEL DIMENSIOIN

SPECIFICATION P-82:81
(UDC NO. 669,586,5)

ZINC COATINGS

PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY
DESIGN DEPARTMENT, POWER

CONTENTS

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SPECIFICATION P-82: 81

(UDC No. 669.586.5)

ZINC COATINGS

0 FOREWORD

0.1 This specification has been prepared by the Design Department of Power Wing, WAPDA and lays down specification for protective zinc coatings applied on iron and steel.

0.2 This standard is intended only for the purpose of procurement of materials and does not include the provisions of a contract.

0.3 This standard is subject to periodical revisions as and when required.

0.4 This specification is mainly based on ASTM A. 90 and A. 219, A.153.68, A.154.55, A.525.67, A.121.66, B 261-63, BS 443: 1961.

1 SCOPE

1.1 The specification lays down test for the zinc coatings which has been deposited either by Hot Dip method or by Electrodeposit Method on the articles as classified below. It also covers the weight of zinc coatings which shall be required per square meter of the surface area or its thickness.

Classification	Description of articles
Class A-Fabricated products	Fabricated products from rolled, pressed and forged steel shapes, channels, angle iron, T shapes, plates, bars and strips e.g. structural poles, tubular poles, pipes, channels and angle iron for platforms of pole mounting transformers, capacitors and voltage regulators, lattice steel cross bracket etc.
Class B-Castings	Castings, iron, malleable iron and steel.
Class C-Rolled pressed and forged articles	Rolled, pressed and forged articles such as insulator pins, anchor-shackle, eye-nuts, clamps, cotter pins, thimbles, covers, deadend clamps etc.
Class D-Nuts and bolts etc.	Nuts, bolts, washers, nails, rivets, screws and similar articles.
Class E-Steel Wires	Steel structural strands, steel wire strands for overhead transmission lines, guys, messengers, spur wires, tie wires and barbed wires.
Class F-Steel sheets	Steel sheets of all types and sizes

2 MATERIAL

2.1 The zinc used in electro-depositing and hot dip galvanizing shall be slab and shall conform to the following chemical composition:

Lead Max	1.6 percent
Iron Max	0.05 percent
Cadmium Max	0.50 percent
Zinc Min	98.0 percent

3 WEIGHT AND THICKNESS OF ZINC COATINGS

3.1 The weight of zinc coating by hot dip method on various articles shall be as per table-I below or otherwise specified in the relevant standards.

TABLE-I: WEIGHT OF ZINC COATINGS

Classification		Description of articles	Wt of Zinc Coating Individual samples gm/sqm	Average of 3 samples gm/sqm
Class A Fabricated Products		Fabricated products from rolled pressed and forged steel shapes, channels and angle iron, T-shapes, plates bars and strips e.g. structural poles, tubular poles, pipes, channel and angle iron for platform of pole mounting transformers, capacitors and voltage regulators, lattice steel crossarm bracket etc.		
	i)	When the thickness of steel is 3 mm to 6 mm	550	610
	ii)	6mm and heavier material	610	700
	iii)	Pipe for service-mast only	350	400
	iv)	Distribution transformer station hardware & cross-arm braces.	450	500
Class B Castings		Castings, cast iron malleable iron and steel	550	610
Class C Rolled, pressed and forged articles		Rolled, pressed and forged articles such as anchor shackle, eye-nuts, clamps, cotter pins, thimbles, covers, deadend clamps etc.		
	i)	4.75mm and over in thickness and over 200mm in length	550	610

	ii)	Under 4.75 mm in thickness and over 200 mm in length.	380	460
	iii)	200mm and under in length and any thickness	330	400
	iv)	Hardware of service-mast other than pipe, insulator pins & D-shackle assembly	450	500
Class D Nuts and Bolts etc.	i)	Bolts, nuts and drive screws (over 9.5 mm in diameter) and similar articles, transmission tower bolts, washers 5 mm and over in thickness.	305	380
	ii)	Screws and bolts (9.5 mm and under in diameter) rivets, nails and similar articles, washers under 5 mm in thickness.	260	305

Class E — Steel Wires

The weight of zinc coating on steel structural strand, steel wire stand for overhead transmission lines, guys, messengers, spur wires and tie wires for similar purposes shall be as under:-

Stranded wire dia mm	Weight of zinc coating (gm/sqm)
0.20 to 0.30	45
0.31 to 0.39	60
0.40 to 0.50	90
0.50 to 0.79	120
0.75 to 1.00	150
1.00 to 1.50	170
1.50 to 2.00	(200)
2.01 to 2.50	225
2.50 to 3.00	250
3.01 to 5.00	275
5.01 and larger	300

ii) The minimum weight of zinc coating in gm/sqm on barbed wires shall be as under:

dia mm	
2.5 including and above	250.00
2.0 to 2.4 mm	200.00
1.5 to 1.9 mm	1500.00

Class F **Steel Sheets**

The minimum weight of zinc coating in gm/sqm on galvanized steel sheets shall be as under:-

Coating class	Average of triple spot test	Min. single spot test
2.75	716.00	610.00
2.5	640.00	550.00
2.25	564.00	490.00
2.00	503.00	427.00
1.75	427.00	366.00
1.50	350.00	305.00
1.25 commercial	274.00	244.00

3.2 Thickness of Zinc Coating by Electrodeposit Method

3.2.1 The minimum and average thickness of zinc coating, except threaded parts, by electrodepositing on steel articles shall be as under:-

Coating class	Local thickness (mm)	Average thickness (mm)	Application conditions
Class G	.025	.038	Outdoor
Class H	.008	.013	Indoor

3.2.2 The minimum and average thickness of zinc coating on threaded parts of steel articles shall be as under:-

Diameter (mm)	Average thickness minimum (mm)	Average thickness maximum (mm)
1.50 to 6.00	0.005	0.0065
6.01 to 12.00	0.0065	0.008
12.01 to 20.00	0.008	0.010

3.3 One gram of zinc per square meter of surface, based upon mathematical calculation, shall correspond to a coating thickness of 0.00014 mm.

4 TEST METHODS

4.1 Weight of Zinc Coating on Galvanized Sheets

4.1.1 Test Samples

Test specimens shall be (50 ± 0.25)mm square, except for material narrower than 50 mm wide, in which case test specimens shall be of such a length that the area of the specimen is 2500 sq mm. When it is not possible to secure a specimen of 2500 sq mm in area, a smaller size may be used but it is recommended that a specimen of not less than 1,300 sq mm be used.

4.1.1.2 The specimens shall be clean, they shall be washed with solvent naphtha or other suitable solvent, then with alcohol and dried thoroughly.

4.1.2 Test Method

4.1.2.1 Reagents

i) Antimony chloride solution:-

Dissolve 20 grams of $Sb_2 O_3$ or 32 gm of $Sb Cl_3$ in 1000 ml of HCl (sp.g. 1.19)

4.1.2.2 Weigh the specimens obtained in accordance with 4.1.1 to the nearest 0.01 g. After weighing immerse each specimen singly in a solution made by adding 5 ml of antimony chloride to 100 ml of HCl (specific gravity 1.19) to cover the specimen and allow to remain therein until the voilent evolution of Hydrogen has ceased and only a few bubbles are being evolved. This requires about 15 to 30 sec. The same solution may be used repeatedly until the time required for stripping becomes inconveniently long. The temperature of the stripping solution shall at no time exceed 38°C. After stripping, wash the specimen by scrubbing them under running water, dip in hot water and wipe or blow dry. Again weigh the specimen to the nearest 0.01 g.

4.1.2.3 Calculations

i) The loss in weight represents the weight of zinc coating in grams on the samples; to find the weight of zinc coating per sq meter proceed as follows:-

$$\text{Wt of coating in grams per square meter of steel surface} = \frac{\text{Loss in wt in grams} \times 10^6}{A}$$

Where A = Area of stripped sample in sq mm

4.2 Weight of Zinc Coating on Galvanized Wire

4.2.1 Test Sample

4.2.1.1 The specimens of galvanized wire may be of any length over 300 mm, but preferably about 600 mm. Where a continuous length is not available, shorter specimens totalling 300 mm but preferably 600 mm shall be used.

4.2.1.2 The specimen shall be cleaned by washing with solvent naphtha or other suitable solvent, then rinsed with Alcohol and dried thoroughly.

4.2.2 Test Method

4.2.2.1 Test method shall be the same as described in clause 4.1.2.

4.2.3 Test Results

4.2.3.1 Calculate the weight of zinc coating as follows:

$$C = \frac{W_1 - W_2}{W_2} \times d \times M$$

Where C = Wt of zinc coating in grams per sqm

W_1 = Original weight of specimen in grams

W_2 = Weight of stripped specimen in grams

M = a constant = 1958

d = diameter of stripped wire in mm

4.3 <u>Weight of Zinc Coating on Articles Covered under Class A,B,C&D</u>

4.3.1 <u>Test Samples</u>

i) Samples for weight of coating determination, shall be selected in accordance with clause 6.4 or as specified in the relevant specification.

ii) In the case of threaded articles, such as bolts and screws, the determination shall be made on a portion of the article that does not include any thread.

iii) The specimens shall be cleaned by washing with solvent naphtha or other suitable solvent, then rinsed with Alcohol and dried.

4.3.2 <u>Test Procedure</u>

The procedure shall be the same as described in clause 4.1.2.

4.3.3 <u>Test Results</u>

4.3.3.1 Determine the total coated area of the specimen to the nearest 5 sq mm. Alternatively for specimens of uniform thickness of base metal, such as piece of plate of pipe, determine the average thickness of the specimen to the nearest 0.25 mm.

4.3.3.2 <u>Calculation</u>

Calculate the weight of zinc coating by using the formula:

$$C = \frac{W_1 - W_2}{A} \times N$$

Where C = Wt of zinc coating in gm/sqm of surface

W_1 = Original wt of specimen in grams

W_2 = Weight of stripped specimen in grams

A = Coated area of the specimen in sq mm.

N = A constant = (1000400)

(b) If the specimen has a uniform thickness of base metal, the weight of the zinc coating may be calculated using the following formula:-

$$C = \frac{W_1 - W_2}{W_2} \times G \times Z$$

Where C = Wt of zinc coating in gm/sqm of the surface

W_1 = Original weight of the specimen in grams

W_2 = Weight of stripped specimen in grams

G = Thickness of stripped specimens in mm

Z = A constant = 3935

4.4 Test for Thickness of Electrodeposit Coating

4.4.1 Microscopic Test

The thickness of coating shall be determined on cross-sections taken perpendicular to the significant surfaces by the microscopic method described in the methods given below.

4.4.2 Test Specimens

4.4.2.1 To determine compliance with a specified minimum thickness of electrodeposited zinc, section the specimen at one or more significant surface where such a minimum may be expected.

4.4.3 Test Method

4.4.3.1 Hold the specimen rigidly and in such a position that the surface to be tested is perpendicular to the flat surface that is to be ground and polished (A deviation of 10 degrees from normal introduces an error of about 2% in thickness). The pieces may be plated first with a relatively thick coating of copper to protect the edges during grinding and polishing. On zinc deposit the first layer of copper from a cyanide solution after which, if desired, an acid copper solution may be used.

4.4.3.2 Grind and polish the section to be examined by regular metallographic methods, using successively finer abrasives the last being no coarser than 500 mesh. Polish zinc coating with minimum pressure in the direction from the hard basis metal to the soft coating, and alternatively at 45° and 135° angle to the plated surface.

4.4.3.3 Then treat the surface in such a manner as to obtain the maximum contrast between the coatings and the adjacent metals. Obtain such contrast by etching either the coating or the adjacent metal by an appropriate reagent. Suitable etching is desirable even when a contrast exists, since it will remove any soft metal that may have spread over a harder metal.

4.4.3.4 The following typical reagents are suitable for etching plated coatings:-

Chromic Acid (CrO_3)	200 g/Litre
Sodium Sulphate Na_2SO_4	15 g/Litre

4.4.3.5 Measure the thickness of coating at any desired point on the exposed section by either of the methods described below:

i) Measure the thickness with a filar micrometer ocular that has been calibrated in order to determine the value of the unit scale division against a scale graduated so accurately that the error will not exceed 2% for example, the scale may be graduated to 0.01 mm.

ii) Project the image of the specimen especially of those specimens having very thin coatings, at a known and properly calibrated magnification on the ground-glass focusing plane of the camera of a metallographic microscope. Measure the width of the projected line of deposit with a graduated linear scale, the reading divided by the magnification shall give the thickness of the coating.

4.5 Adherence of the Coating Tests

4.5.1 Galvanized Sheets.

4.5.1.1 Galvanized steel sheets shall withstand a bend through 180° in any direction without flaking of coating on the outside surface.

4.5.1.2 The sample under test shall be gripped in a hand operated vice with smooth jaws and shall be bent through 180° over a mandrel twice as thick as the sample if weight of zinc coating is equal or more than 525 grams/sq.m. The sample shall be folded over a mandrel equal to the thickness of sample if the weight of zinc coating is less than 525 grams/sq.m.

4.5.2 Galvanized Wire

4.5.2.1 Zinc coated wire shall be capable of being wrapped at a rate not exceeding 15 turns per minute in a close helics of at least two turns around a cylindrical mandrel equal to three times the nominal diameter of wire under test, without cracking or flaking the zinc coating to such an extent that any zinc can be removed by rubbing with the bare fingers.

4.5.3 Articles covered under Class A, Class B and C - Heavy Materials

4.5.3.1 The pivoted hammer may be used to determine adherence of zinc coating on steel products 8 mm thick and heavier covered under class A, B and C. This test is applicable to flat surfaces only and shall not be used on round and curved surfaces. The hammer used shall conform to fig 4. The hammer blow shall be controlled by clamping or holding the pivoted base of the handle firmly on a horizontal surface of the galvanized member and allowing the hammer head to swing freely through an arc from vertical position to strike the horizontal surface. As illustrated in fig 2 the test shall consist of two or more standard blows forming parallel impressions with 6.5 mm spacing along a common axis so located that no part of an impression shall be closer than 13.0 mm to the edge of the member. Removal or lifting of the coating in the area between the impressions shall constitute failure. An extruded ridge less than 3 mm wide shall be disregarded. The specimen shall be tested in several places throughout its length.

4.5.4 Articles covered under Class A, Class B and Class C - Small and Light Materials.

4.5.4.1 Small and light materials which are liable to deflect or deform under the hammer blow and curved or round articles which cannot be hammered properly should be tested by this method.

4.5.4.2 The adherence of zinc coating to the surface of the base metal shall be determined by cutting or prying with a stout knife, applied with considerable pressure in a manner tending to remove a portion of the coating. It shall only be possible to remove small particles of the coating by paring or whittling and it shall not be possible to peal any portion of the coating so as to expose the base metal.

4.6 Uniformity of Coating Test

4.6.1 Test Solution

4.6.1.1 The copper sulphate solution shall be made by dissolving approximately 36 parts by weight of commercial copper sulphate crystals in 100 parts by weight of distilled water. Heat may be used to complete the solution of copper sulphate crystals. If heated, the solution shall be allowed to cool. The solution shall then be agitated with an excess of powdered cupric hydroxide $Cu(OH)_2$ about 0.81 gms/litre of solution. The presence of an excess of cupric hydroxide will be shown by the sediment of this reagent at the bottom of the vessel. The neutralized solution shall be allowed to stand for 24 hour and then filtered or decanted.

4.6.1.2 The test solution shall have a specific gravity of 1.186 at 18^{o}C. To adjust a solution of improper specific gravity, add distilled water when the specific gravity is high, and add a copper sulphate solution of a higher specific gravity when the test solution is low in specific gravity.

4.6.1.3 Wire specimens shall be tested in a glass container at least 50mm in inside diameter for 2.5 mm dia wire and smaller, and at least 75.0 mm in inside diameter for wire larger in diameter than 2.5 mm dia. The container shall be filled with fresh test solution to a depth of at least 100.0 mm. This quantity of solution shall be used for the simultaneous testing of one to seven test specimens. The solution shall be discarded after completion of the test and fresh solution used for any additional tests.

4.6.1.4 For testing articles other than wire, the quantity of copper sulphate solution required for each test will depend on the superficial area of the test specimen and the weight of coating. The quantity should not be less than 40 ml per gm of zinc coating on the specimen and shall be sufficient to cover the specimen so that the top surface of the solution is at least 13 mm above the top of the section of the specimen under test. The solution shall be discarded after completion of the test and fresh solution used for any additional tests.

4.6.2 Test Samples

4.6.2.1 The specimens selected for test shall be free from abrasion or cuts in the zinc coating, except those which may occur during manufacture or the preparation of the specimen for testing. Specimens of wire may be hand straightened.

4.6.2.2 The specimens shall be cleaned with a volatile organic solvent such as carbon tetrachloride, gasoline, or benzene, then rinsed with alcohol, and finally, thoroughly washed with clean water and wiped dry with clean cotton cloth. Test specimens shall be brought to a temperature of 15° to 21°C prior to beginning of the test.

4.6.2.3 Abnormal cases may arise when, by reason of unusual surface conditions, the copper sulphate solution will not act normally on the zinc coating. If there is any question of abnormality of performance of test specimens, the specimens shall be discarded and new ones selected. The new specimen shall be cleaned in alcohol, rinsed and wiped dry and then immersed for 3 minutes in a solution consisting of 1 part by volume of ammonium hydroxide (sp. gravity 0.90) and nine parts of water. The specimens may be scrubbed with cotton cloth during this immersion. After cleaning the specimens shall be washed and wiped dry and then tested in accordance with the procedure laid down below.

4.6.3 Test Method

4.6.3.1 The test specimen shall be immersed in the copper sulphate solution, which shall be maintained at a temperature of 16 to 20°C. The specimens shall remain in a fixed position in the solution for exact 1 minute. If a ½ minute dip is specified, it shall be given to the specimens after completion of all of the 1 min dip. There shall be no agitation of the solution during the immersion period and the specimen shall not be allowed to touch each other or the sides of the container. After each dip, the specimens shall be washed immediately in the rinsed water, and a fibre bristle brush shall be used to remove any copper deposit that may have formed on the zinc coating. Before returning the specimens to the test solution they shall be well drained of excess rinse water and wiped dry with a clean cloth.

4.6.3.2 Successive dips of 1 min. each shall be continued, with washing and wiping of the test specimens after each dip, until the specimens have withstood the required number of dips specified in table-II or until the end point has been reached.

TABLE-II: WEIGHT OF COATING AND NUMBER OF DIPS

Weight of Coating gm/sqm	No of Dips 1 minute	half minute
300 and above	4	-
270 to 299	3	1
240 to 269	3	-
180 to 239	2	-
140 to 179	1	1
90 to 139	1	-
75 to 89	-	1

4.6.3.3 A recommended device for holding test specimens of wire in a fixed position is shown in fig 1. A similar device may be used for holding specimens of other small articles that are not required to be fully immersed in the test solution. Specimens that are completely immersed may be suspended by a string.

4.7 Visual Inspection

4.7.1 The galvanized surface shall be free from such imperfection as lumps, uneven coatings, blisters, gritty areas, uncoated spots, ash and flux inclusions, globules or heavy deposits of zinc which will interfere with the intended use of the material will not be permitted.

4.7.2 Following is the list of defects, their significance and possible remedies:-

Condition	Causes	Recommended Actions	Ground for Rejection
Bare Spots	Paint, grease or oil residues	Check cleaning particles	Materials may be
	Scale or rust residues	Check pickling particles	accepted where bare
	Residual welding slag	Blast-clean welds, Avoid coated rods.	spots are in accordance with
	Breakdown of preflux coating	Check preflux and drying conditions	clause 4.7.2.

	Aluminium content of bath too high	Regulate aluminium additions	
	Rolling defects in basis steel	Check steel supply	
	Articles in contact during galvanizing	Keep articles separated.	
General Roughness	Analysis or original surface condition of steel,	Check steel supply	Material may be accepted provided adhesion is good and degree of roughness is not too critical.
	Overpickling	Reduce pickling use inhibitor.	
	High galvanizing temperature and/or long immersion time.	Adjust galvanizing conditions	
Pimples	Entrapped dross particles	Avoid agitation of dross layer check carry-over of pickle salts.	Material with finally disposed pimples covering not more than 0.5% of the area may be accepted.
Lumpiness and Runs	Withdrawal speed too high	Remove work slowly	Materials of class ABC may be accepted whereas of class D,E, F rejected.
	"Cold" galvanizing bath	Increase temperature	
	Delayed run-off from seams, joints bolt holes, etc.	Remove work slowly	
	Articles in contact during withdrawal.	Keep articles separated	
Flux Inclusion	Steel flux burnt on during dipping	Refresh or renew flux blanket	Materials shall not be accepted.
	Surface residues on steel	Check steel preparation	
	Flux picked up from top of bath	Skim before withdrawal.	

4.7.3 Articles covered under class A & F shall be completely free from uncoated spots. However small localized uncoated spots on fabricated pressed, forged and casted articles covered under class A, B & C may be ignored upto maximum of 0.25% of the total area. The area of such individual spots shall not exceed 0.5 square mm. Uncoated spots shall be patched with galvanizing repair paint.

4.8 Embrittlement Tests

4.8.1 Galvanized Angle Test (for angle irons only)

4.8.1.1 Test Requirements

i) The elongation measured in accordance with clause 4.8.1.2 (i) shall not be less than 5 percent except as specified in para 4.8.1.2 (ii).

ii) When the specimen does not show 5 percent elongation, the reduction in thickness shall be measured in accordance with clause 4.8.1.2 (ii). The sum of the percentage of elongation plus the average percentage reduction of thickness shall not be less than 10.

4.8.1.2 Test Procedure

i) For determining the elongation after fracture, a 51 mm gauge length (Fig 2) shall be prick-punched in the middle of the edge of the vertical leg of the angle along a line parallel to its length and centred directly under the hole. After the test, the sum of the distance along this line from each punch mark to the corresponding edge of the fracture shall be measured to 0.25 mm with a flexible scale, and the percentage of elongation calculated. For specimens under 13.0 mm in thickness or those in which the distance from the edge of the hole to the edge of the angle is less than 10 mm, the elongation shall be measured over a 25 mm guage length.

ii) For determining the percentage reduction of thickness after fracture, the reduction shall be measured with a ball point micrometer at the 3 locations indicated in fig 3; namely (a) outer side of hole, (b) inner side of hole, (c) middle of leg. The percentage reduction of thickness shall be calculated on the basis of the original thickness of the angle and the average of the three values at a, b and c.

iii) The length of the test specimen and the distance between the supports are shown in the following table:-

Length of angle L (mm).	Length between supports L_1 (mm)	Minimum length L_2 (mm)
Upto 100 mm incl.	356.0	457.0
Over 100 mm to 150mm incl.	508.0	610.0
Over 150 mm to 200mm incl.	762.0	915.0

iv) The kind of hole, punched, sub punched and reamed, or drilled, shall be that employed in the fabricated material which the specimen represents. The dimensional values, diameter, and location of hole, shall be not less than those employed in the structural details. Care shall be taken not to place the hole near stamped or rolled____ in identification marks.

v) The test shall be made upon galvanized specimens having a temperature not below 60° and not over 90°F when tested.

vi) The test may be made in a universal testing machine, or by other means such as a press or bulldozer with the load applied slowly.

4.8.2 Embrittlement Tests for Materials covered under class B,C & D.

4.8.2.1 The test is suitable for galvanized steel hardware of such shape and size that permit bending such as bolts, tower steps, insulator clevises, braces, rods etc. Clamp one end of the article in a vice and bend the other end through an angle of 90 degree of about a diameter equal to the dia or thickness of the article under test. A suitable length of pipe may be used as a lever to assist bending. The article after bending shall show no cracks on the outside surface of bend. If such a test is made on threaded articles, it shall be made on un-threaded portion. In case of completely threaded articles, the threads shall be removed and the 90 degrees bend shall be about a diameter equal to the reduced diameter of the article.

4.8.2.2 Castings and steel hardware of such shape or size that they do not permit bending, may be struck a sharp blow with a hammer of suitable weight. If the material is not embritted, it should not crack under such a blow. However, if the article is tested to destruction, a white lustrous, coarse grain appearance of the resulting fracture is indicative of embrittlement and shall be cause for rejection.

5 TESTS

5.1 Tests on galvanizing shall be carried out as per table - III below or otherwise specified in the relevant standard. Tests where applicable are marked 'O'.

TABLE-III TESTS ON GALVANISING

Test	Class A	Class B	Class C	Class D	Class E	Class F	Articles galvanized by electrodeposit method
Visual Inspection	0	0	0	0	0	0	0
Wt. of zinc coating (on hot dip articles)	0	0	0	0	0	0	X
Thickness of zinc coating	X	X	X	X	X	X	0
Uniformity of coating test	0	0	0	0	0	0	X
Adherence of coating test	0	0	0	X	0	0	0
Embrittlement test	0	0	0	0	X	X	X

6 TEST SAMPLES - ACCEPTANCE AND REJECTION

6.1 The manufacturer shall provide all necessary facilities including testing equipment for carrying out tests free of cost to WAPDA. The cost of test samples destroyed during tests shall be borne by the manufacturer.

6.2 The WAPDA representatives shall have access at all times while work on WAPDA's contract is being performed. The manufacturer shall afford the WAPDA representative all reasonable facilities to satisfy him that the galvanizing is being furnished in accordance with the specification.

6.3 For visual inspection, articles shall be grouped into lots and test specimens shall be selected from a lot at random in accordance with table-IV. If the number of defective units does not exceed one, the lot shall be accepted. If the number of defective units exceeds two, the entire lot shall be rejected. In case the defective being two, another sample of double the quantity given in table-IV shall be selected at random and the test repeated. In case of any failure from the second selection, the entire lot shall be rejected.

6.4 Test specimens from each sample for determination of compliance to the tests specified in clause 8.2, 8.3, 8.4 and 8.5 shall be taken from each lot. The lot shall consist of a quantity

TABLE-IV

Material Description	Lot	No. OF SAMPLES Visual Inspection	Wt. of galvanizing test or thickness of zinc coatings	Uniformity and adherence of coating test	Embrittlement Test
1. Class A, B, C & D					
i) Fabricated, rolled, pressed, forged and cast articles covered under class A,B, C & D not more than 300 mm in length.	1000 units	100 units	3 units	3 units	3 units
ii) Fabricated, rolled, pressed, forged and cast articles covered under class A,B, C & D more than 300 mm in length	500 units	100 units	3 units	3 units	3 units
2. Class E					
Galvanized steel wires, barbed wires binding wires etc.	100 coils or 10 km in length of wire of same size in form of coils whichever is less.	10 coils	3 sample coils shall be selected from each lot and test specimens shall be cut from each coil as per clause 6.5 of this specification.	3 sample coils shall be selected from each lot and test specimen shall be cut from each coil as per cl. 6.6 of this specification	
3. Class F					
Galvanized steel sheets.	500 sheets of same size or 1000 kg in wt. whichever is less.	25 sheets	3 sample sheets shall be selected from each lot and test specimens shall be cut from each coil as per clause 6.5 of this specification	3 sample coils shall be selected from each lot and test specimen shall be cut from each coil as per clause 6.6 of this specification	
4. Class G and H					
Galvanized articles by electrodeposit method.	The procedure for sampling shall be the same as described above for hot dip galvanized articles.				

as specified in table-IV below or as otherwise specified in the relevant specification. If any sample fails to comply with the requirements laid down in this standard, another set of samples as per table-IV shall be taken from the remaining lot and test repeated. In case of any failure in the second set of samples, the whole lot shall be rejected.

6.5 Test samples from sheets or coils (Class E,F) for determination of weight of zinc coating shall be obtained as follows:

i) When cut from coil, one sample from the centre and two samples from both ends of coil shall be taken.

ii) When cut from sheet, one sample from the centre and two samples from diagonally opposite corners shall be taken.

6.6 Test specimens from each sample sheets and coils for determination of adherence and uniformity of coating shall be obtained as follows:

i) When cut from coil, sample shall be selected from one end of the coil.

ii) When cut from sheet, sample shall be taken from one corner of the sheet.

7 PASSIVATION TREATMENT

7.1 Zinc coatings applied by electrodeposit method shall be given full passivation treatment for maximum protection from corrosion by the following process.

7.2 The zinc plated components shall be well rinsed, then immersed for 5 to 10 seconds in a passivation solution of following composition:

Sodium dichromate	182 g/litre
Free sulphuric acid	6 ml/litre

After passivation the components shall be well rinsed in running water and then dried in warm air.

7.3 Passivation process other than one specified above, may be used subject to prior approval by WAPDA.

Encls: Figures 1,2,3, 4 and table IV.

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m.y

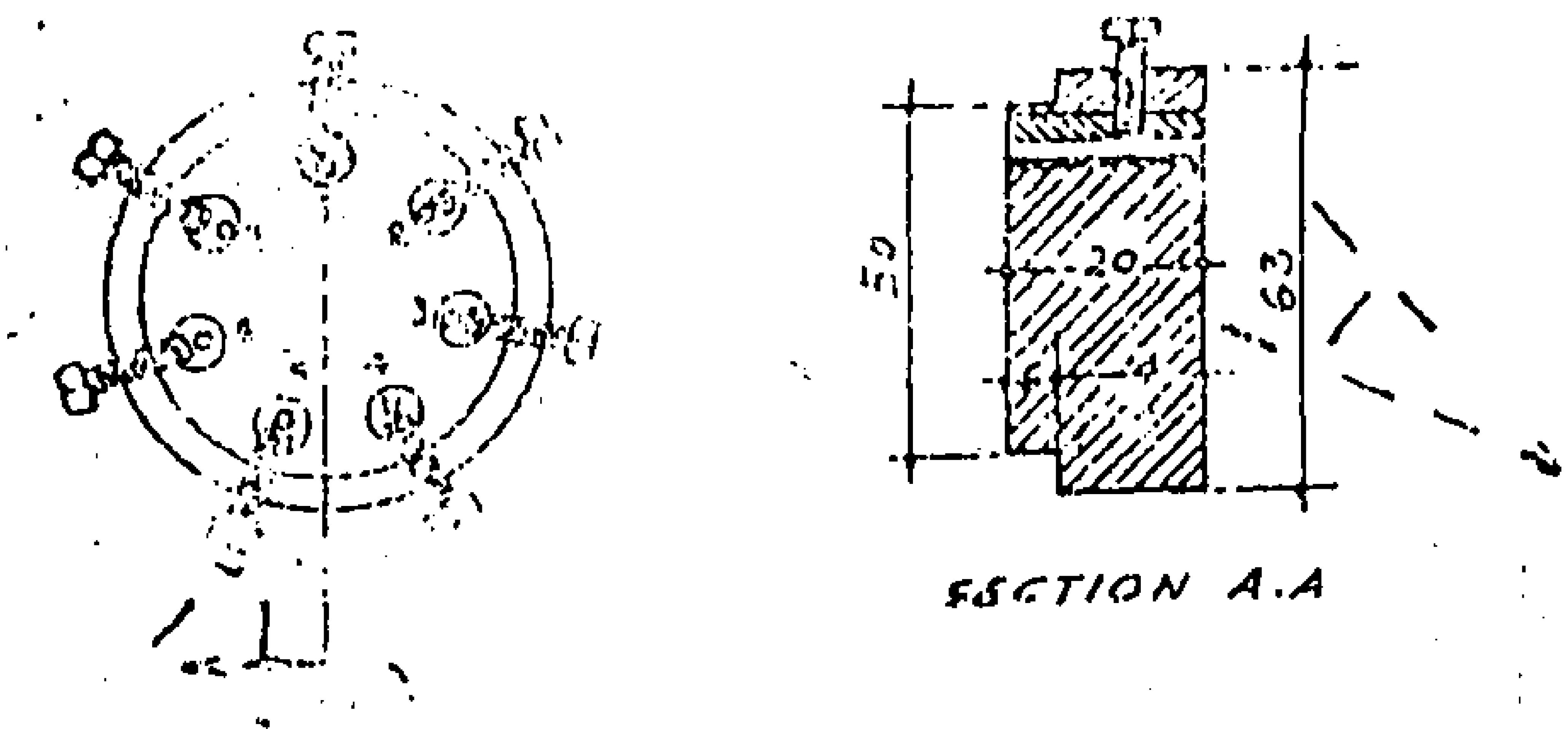

FIG. 1

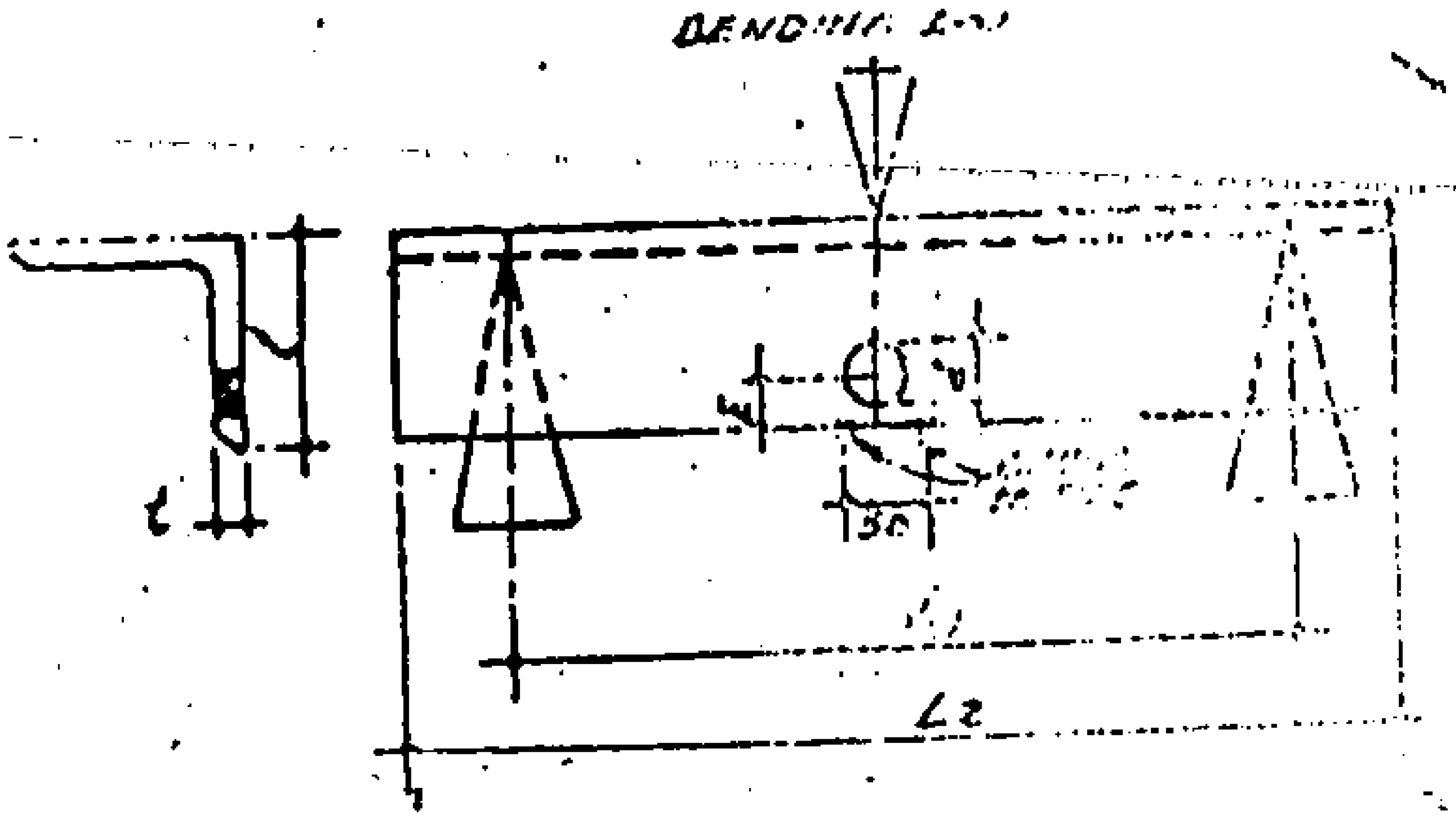

FIG: 2

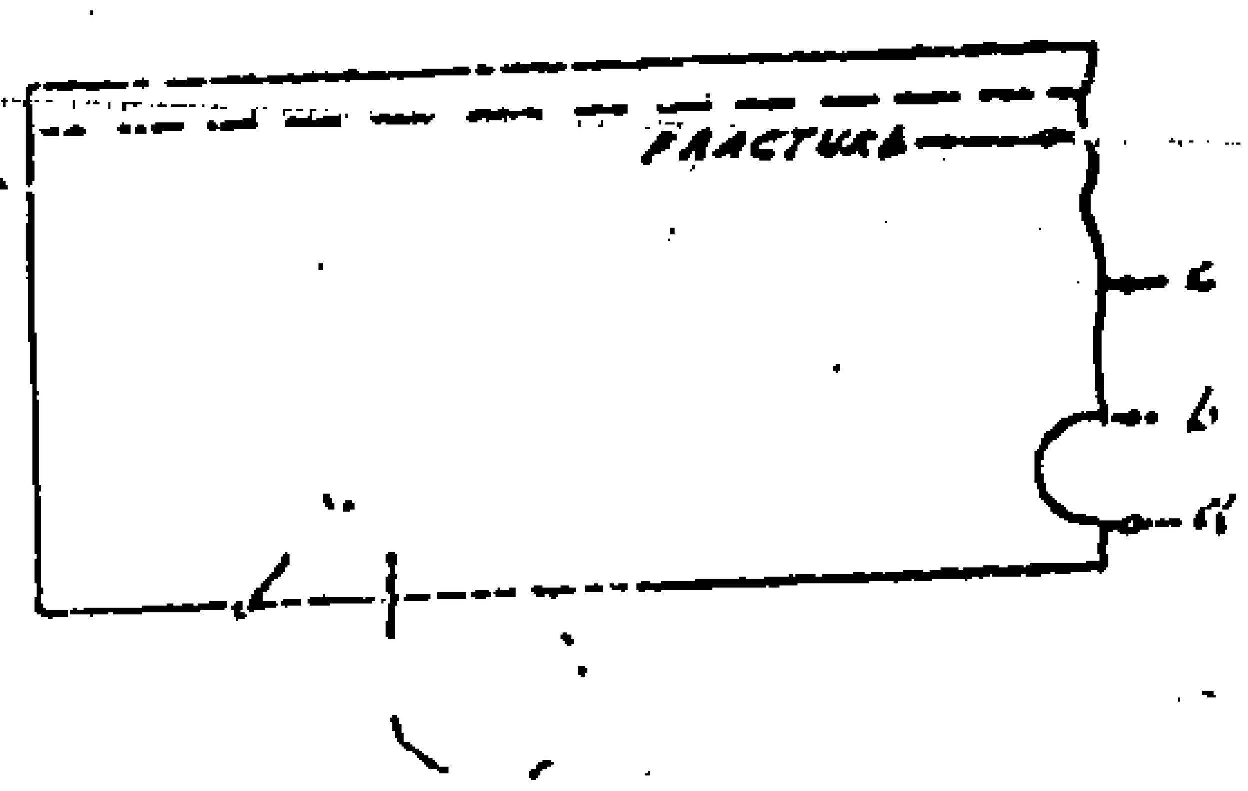

FIG. 3

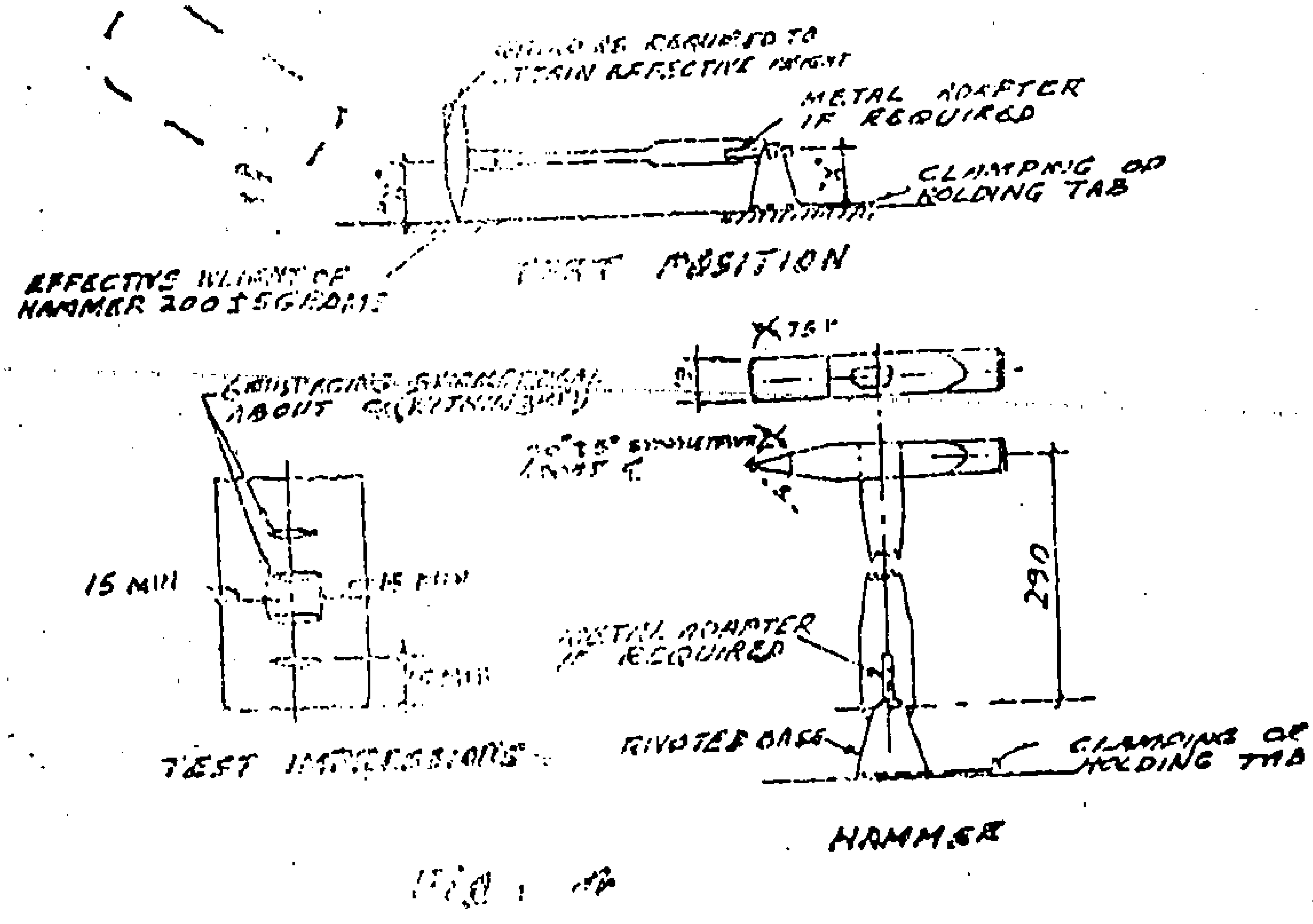

FIG. 4

SPECIFICATION P-139:80

FABRICATION OF STEEL STRUCTURES

PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY
DESIGN DEPARTMENT,POWER.

CONTENTS

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SPECIFICATION P-139:80

FABRICATION OF STEEL STRUCTURES.

AMENDMENT NO.1, DATED: 3RD OCTOBER,1982.

1. **Clause 4.3**

Add the following para at the end of clause 4.3

"For the high tensile steel (yield point equal or higher than 35 kg/mm^2) holes shall be directly drilled at the definitive diameter or punched and reamed out; The difference between the punched and reamed diameter shall be at the minimum 4 mm."

2. **Clause 4.6**

The following para is to be added at the end of the clause 4.6.

"Diameter of a punch hole shall not vary in all the thickness of the member or gusset. The difference between both hole diameters on each face of the piece shall be lower than the tenth of the punched thickness, with a maximum of 1.2 mm. For the thickness lower than 5 mm, maximum difference is fixed at .5 mm."

3. **Clause 7.2.1**

Delete the clause 7.2.1 and add the following:-

1. Visual examination
2. Varification of dimension and weight
3. Assembly test
4. Chemical Composition (check analysis)
5. Tensile Tests
6. Bend tests
7. Impact tests
8. Galvanizing tests

4. **Clause 9.8**

Add the following after clause 9.7

Impact Tests

"The test shall be performed in accordance with ISO 630."

SPECIFICATION P-139: 80

FABRICATION OF STEEL STRUCTURES

0 FOREWORD

0.1 This standard has been introduced by WAPDA and has been prepared by the transmission line section of the office of the Chief Engineer (Design).

0.2 This standard is intended only for the purpose of technical specification to facilitate fabrication of steel structures and does not include provision of contract.

0.3 This specification is subject to periodic revision as and when required.

1 SCOPE

This specification covers fabrication, galvanizing, testing and packing of transmission line towers and sub-station structures.

2 STEEL

2.1 In fabricating structures the contractor shall use structural steels having chemical composition and tensile properties as specified. The steel shall be made either by open hearth, basic oxygen or electric furnace process.

2.2 Requirement

2.2.1 Chemical Composition

2.2.1.1 The steels shall conform to the following chemical composition.

Element	Composition Percent	
	Mild Steel	High Tensile Steel
Carbon	0.26	0.20
Manganese	0.85	1.35
Phosphorus Max.	0.04	0.04
Sulphur Max.	0.05	0.05

2.2.1.2 The Contractor may propose structural steel conforming to latest applicable industry standards specification and recommended practices having different chemical composition provided such steel has the yield point and min. elongation as specified in clause 2.2.2. In this case the type and specifications of steel will have to be approved by WAPDA. The following information shall be supplied by the Contractor:

- Ultimate tensile strength
- Minimum Guaranteed yield strength
- Minimum elongation
- Detail of test piece
- Chemical Composition

2.2.2 Tensile Properties

The steels shall conform to the requirements as to tensile properties prescribed below.

	Mild Steel	High Tensile Steel
Tensile strength kg/mm^2		
Minimum	40	50
Maximum	56	80
Yield points kg/mm^2		
Minimum	26	35
Elongation in 200mm guage length percent, minimum		
Upto 8mm thickness	16	15
Over 8mm thickness	20	18

2.2.3 Bend Test Requirement

The steels shall withstand the following Bend Test Requirements.

Type of Material	Thickness of Material	Ratio of bend diameter to thickness for specimen
Mild Steel	Upto 25 mm	1
High Tensile Steel	Upto 25 mm	2

3 NUTS AND BOLTS

All bolts and nuts shall be made from mild steel to WAPDA Specification P-19 and shall be of size M 16. The bolts shall be provided with one flat washer under each nut.

Washers shall not be less than 5 mm thickness and only one thickness of washer shall be used. The diameter of the washer hole shall be 1.5 mm larger than the bolt diameter and the outside diameter of washer shall not be less than 1.5 mm larger than the diagonal of the nut. All connection bolts, nuts, lock nuts and washers shall be furnished in excess of actual number required in quantity at least 5% greater than actual requirements sufficient to compensate for normal field losses.

4 FABRICATION

4.1 All fabrication shall be performed according to approved drawings in a thorough and workman like manner in accordance with the best practice of a modern shop. All structural material shall be straight and cleaned of all rust and dirt before being laid out or worked in any manner. Necessary straightening shall be done in a manner that will not injure the material. Sharp kinks or bends shall be a cause for rejection.

4.2 In shearing and punching only sharp dies and punches shall be used, shearing and punching shall be done to guage and no variation in length shall be allowed except where otherwise noted on the shop detail drawing. No variation shall be allowed in a group or cluster of holes, and the centre to centre distance between the end holes in a piece shall not vary more than 1 mm.

4.3 Bolts holes shall be 1.5 mm to 2 mm larger than the normal bolt diameter. Bolts holes shall be cylinderical and perpendicular to members, shall be clean out and without torn or ragged edges and shall be free of burrs, rough edges, and punch cracks. Holes shall be accurately located and well matched.

4.4 Welding

All welding shall be performed in accordance with the latest edition of the "Code for Arc and Gas Welding in Building Construction," as formulated by the American Welding Society. A shield-arc welding process shall be used. All welds shall be as shown on the drawings and shall be made in such a manner that residual shrinkage stresses will be reduced to a minimum.

4.5 Marking

All structural members shall be marked with the correct designation shown on the shop drawing. Marking shall be done by stamping the members prior to galvanizing with numerals or letters of 12 mm minimum height, and shall be clearly legible after galvanizing.

4.6 Tolerances

Ease of assembling the structure in the field is of utmost importance. The structure shall be so manufactured that all members carrying the same mark shall be interchangable when assembled. The structure shall fit without undue pressing and no reaming or drifting of holes shall be required. When erected, the structures shall not deviate from the vertical by more than 1/300.

The Contractor shall be responsible for the correct fitting of all parts and shall replace free of cost any defective materials discovered during erection and shall pay all costs of the correction in the field of any errors not previously discovered.

The Cross sectional area or weight of each structural size shape shall not vary more than 2.5% from the theoratical or specified amounts.

The permissible variation from dimensions for structural size steel shapes shall not exceed the prescribed limits in ASTM A6.

5 GALVANIZING

5.1 After all the shop work is complete, all structural materials shall be hot dip galvanized to conform to WAPDA Specification P-82. Prior to galvanizing the material shall be drilled, punched, cut or otherwise fabricated as required, freed from burrs, cleaned and thoroughly prepared, so that the zinc coating shall be adherent, dense, smooth, continuous and uniform. It shall also be completely free from lumps, blisters, uncoated or porous spots, black spots, dross, flux or any other imperfection. All structural steel warped by the galvanizing process shall be straightened by re-rolling or pressing. The material shall not be hammered or otherwise straightened in a manner which may injure the galvanized coating.

All bolts and nuts shall be hot dip galvanized including threaded portions in accordance with WAPDA Specification P-82. Nuts shall have finger tight fit on bolts and develop the full strength of bolts.

5.2 Brittleness

All necessary precautions shall be taken in the composition of steel and in its fabrication and preparation for galvanizing to prevent embrittlement of any item or parts of items including bolts and nuts. For detecting embrittlement WAPDA Specification P-82 shall be followed.

6 SIGN PLATES

All the sign plates shall be fired ceramic surfaces on steel base plates. The ceramic enamel shall completely cover the front and back of the plates and also the edges of plates and the interior edges of the attachmer holes. The enamel around the holes shall be protected by means of fibre washers.

7 TESTS

7.1 Manufacture's Tests

The Manufacturer shall select two samples from each heat to carry out the following tests to satisfy himsel that the products comply with the specification.

7.1.1 For Sections and Plates

1. Chemical Composition (Ladle Analysis)
2. Tensile Tests
3. Bend Tests

7.1.2 For Nuts and Bolts

1.	Proof Load test	According to WAPDA Specificatior P-19
2.	Ultimate Tensile Strength test	
3.	Ultimate tensile strength test under eccentric load	
4.	Cold bend test	
5.	Hardness test	
6.	Galvanizing test	

The Manufacturer shall maintain a record of tests carried out by him for examination by Inspector.

7.2 Acceptance Tests

The following acceptance tests shall be carried out.

7.2.1 For Sections and Plates

1. Visual examination
2. Verification of dimensions and weights
3. Prototype tests
4. Chemical composition(Check analysis)
5. Tensile tests
6. Bend Tests
7. Galvanizing test

7.2.2 For Nuts and Bolts

1.	Verifications of dimensions	According to WAPDA Specification P-19.
2.	Visual inspection	
3.	Proof load test	
4.	Ultimate tensile strength test	
5.	Galvanizing test	

The Contractor shall render all necessary assistance to the Inspector in carrying out above mentioned tests.

8 ACCEPTANCE AND REJECTION

8.1 Chemical Composition

To indicate adequately, the chemical composition of a heat or a lot, the minimum number of samples selected to represent the heat shall be as follows:

	No. of Samples
50 tons or more	2
50 tons or less	1

If a piece fails to meet the requirement the lot shall be rejected.

8.2 Tensile Properties

Two tension and two bend tests shall be made from each heat and strength unless the finished material from a heat and strength gradation is less than 50 tons, where one tension and one bend test will be sufficient. However when material from one heat and strength gradation differes 9 mm in thickness, one tension and one bend test shall be made from both the thickness and the thinnest material rolled in that strength gradation regardless of weight represented.

Two tension and two bend tests shall be made on every finished shape for every 10 tons.

If a test piece fails to meet the requirement the lot shall be rejected.

8.3 Assembly Test

One structure of each type shall be tested.

8.4 Galvanising

The acceptance and rejection on the basis of galvanizing test will be according to WAPDA Specification P-82.

8.5 Dimensional and Finish Defects

The number of sample units inspected shall be equal to the first sample size given in Table-V. If the number of defective units found in the first sample is equal to less than the first acceptance number, the lot shall be acceptable. If the number of defectives found in the first sample is equal to or greater than the first rejection number, the lot shall be rejected. If the no. of defectives found in the first sample is between the first acceptances and rejection number, a second sample of the size given by the plan shall be inspected. The number of defectives found in the first and the second samples shall be accumulated. If the cumulative number of defectives is equal to or greater than the second rejection number, the lot shall be rejected.

TABLE-V

Sample size code letters	Sample	Sample Size	Cumulative sample size	Acceptance Number	Rejection Number
2 to 8	First	1	1	0	1
	Second	-	-	-	-
9 to 15	First	2	2	0	2
	Second	2	4	1	2
16 to 25	First	3	3	0	2
	Second	3	6	1	2
26 to 50	First	5	5	0	2
	Second	5	10	1	2
51 to 90	First	8	8	0	2
		8	16	1	2

Sample size code letters	Sample	Sample Size	Cumulative sample size	Acceptance Number	Rejection Number
91 to 150	First	13	13	0	3
	Second	13	26	3	4
151 to 280	First	20	20	1	4
	Second	20	40	4	5
281 to 500	First	32	32	2	5
	Second	32	64	6	7
501 to 1200	First	50	50	3	7
	Second	50	100	8	9

8.6 Nuts and Bolts

The sampling acceptance, and rejection of nuts and bolts will be according to WAPDA Specification P-19.

9 TEST METHODS

9.1 Visual Examination

The test samples shall be examined visually for the following:

Visual Examination

Examination	Defects
Material	Not as specified in relevant clauses.
Construction	Not of the shape given in relevant drg.
Finish	Galvanising not proper, presence of burrs, black and bare spots, dross and projection.

9.2 Verification of Dimensions and Weight

The binding dimensions of the material shall be measured and weighed and shall be as shown on the relevant approved drawings subject to the tolerances given in clause 4.4.

9.3 Assembly Test

One structure of each type shall be assembled completely in the shop to verify the dimensions and suitability for field erection. Reaming or unfair holes shall not be permitted and only a reasonable amount of drifting will be allowed in assembling. Poorly matching holes shall be cause for rejection.

9.4 Chemical Composition Tests

9.4.1 Laddle Analysis

An analysis of each heat of steel shall be made by the manufacturer to determine percentages of the elements specified below. This analysis shall be made from a test ingot taken during the pouring of the heat. The chemical composition thus determined shall be reported to the purchaser and shall conform to the requirements specified in clause 2.2.1.

9.4.2 Check Analysis

9.4.2.1 Analysis shall be made from finished material representing each heat or lot. The chemical composition thus determined shall not vary from the range or limits specified in clause 2.2.1.1 by more than the amounts specified below, but the several determinations of any elements in a heat may not vary both above and below the specified range.

Element	For Mild Steel		For High Tensile Steel	
	Under the Limit	Over the Limit	Under the Limit	Over the Limit
Carbon	.03	.04	.03	.04
Manganese	.06	.08	.09	.12
Phosphorus	-	.01	-	.01
Sulphur	-	.01	-	.01

9.4.2.2 In case of an approved specification as refered to in sub clause 2.2.1.2 the chemical composition and tolerances of the approved specification be applicable.

9.5 Tensile Test

The test shall be performed in accordance with ISO-82.

9.6 Bend Test

The bend test specimens shall stand being bent cold through 180 deg. without cracking to an internal diameter of the specimen as prescribed in clause 2.2.3.

9.7 Galvanising Test

9.7.1 This test shall be carried out on all ferrous parts complying with the following requirements.

1. Weight of zinc coating
2. Uniformity of zinc coating
3. Adherence of zinc coating
4. Embrittlement tests

9.7.2 Test samples for determination of compliance to the tests specified shall be performed in accordance with WAPDA Specification P-82 and shall be taken from each lot. The lot shall consist of a quantity as specified in the relevant specification.

10 PACKING

10.1 All material shall be suitably packed to final destination. Heavy pieces such as legs and large cross arm members may be packed separately or in bundles of not more than 1000 kg. with all pieces in the bundle having the same mark of the same structure. All bundles of angles shall be securely fastened at three or more locations with galvanized steel binding straps not smaller than 1x20 mm of 1350 kg. tensile strength.

10.2 All small pieces such as bolts, washers, plates and other small fittings shall be packed in strong wooden boxes with a gross weight of 50 to 100 kgs. The boxes should be strong enough to withstand rough handling. Bolts of different sizes and lengths shall be packed in separate bags before boxing. Groups of packages or bundles may be packed in the same wooden boxes. In general, separate packages less than about 50 kg. each should not be used.

11 DRAWINGS

11.1 The contractor will be supplied with single line diagram indicating the various dimensions, angle sizes used, sizes of bolts used, type of steel and various strandards/ process to be followed for fabrication and galvanizing of the structure.

11.2 After placing of contract, the contractor shall submit for approval, the following drawings based on single line diagram provided in the clause.

11.2.1 Shop Details Drawings

The detailed drawings shall show shop details including of dimensions, shearing, punching, bevel cutting, bending and identification mark and weight for each member.

11.2.2 Erection Drawings

Erection drawings showing each member with its identification mark, location and position of the outstanding leg of angles, number and size of connection bolts and all erection details.

11.2.3 Footing Installation Drawings

Footing erection drawings showing each member with its identification mark and number and size of connection bolts, and all dimensions required for the proper setting and positioning of anchor bolts or stub angle footings with relation to the centre, of the strcuture.

11.2.4 Bills of Material

Bills of material for each tower shall show the quantity, kind, size, length, weight and assembly mark for each member, including bolts, washers, plates and all fittings complete for each structure.

* * * * * * * *

SPECIFICATION P-162: 81

(UDC 621.315.52)

BARBED WIRE

PAKISTAN

WATER AND POWER DEVELOPMENT AUTHORITY

DESIGN DEPARTMENT, POWER WING

SPECIFICATION P-162:81

BARBED WIRE

AMENDMENT NO.1 DATED: 5TH JANUARY, 1989.

1. Delete 10% minimum elongation in 250 mm from table-1 under clause 3.1.

C O N T E N T S

PRINTING HISTORY

First edition December, 1981

Amendment No. 1 dated 5th January, 1989.

SPECIFICATION P-162: 81

(UDC 621.315.52)

BARBED WIRE

0 FOREWORD

0.1 This standard specification has been prepared by the Standards and Research Directorate of the Design Department (Power), WAPDA, Lahore.

0.2 This specification is intended only for the purpose of procurement of material and does not include the provisions of contract.

0.3 This specification is subject to revision as and when required.

0.4 This specification supersedes PD-76 on Barbed Wire.

1 SCOPE

1.1 Barbed wire is used on 11 kV steel structures and 11kV reinforced concrete poles for anticlimbing purposes.

2 MATERIAL

2.1 The base metal of the barbed wire shall be of good commercial quality of steel wire made from steel produced by the open hearth, basic oxygen or electric furnace process.

3 DIMENSIONS, CHARACTERISTICS AND TOLERANCES

3.1 The size and characteristics of the zinc coated barbed wire shall be as given in table-I.

TABLE - I

Nominal diameter of zinc coated barbed wire. mm	Minimum breaking strength single wire Kg	Minimum elongation in 250 mm	Net weight of barbed wire on each reel Kg	Shape of Barbs
2.00	115	10%	50	Round

3.2 The permissible variation from the nominal diameter of barbed wire shall be $\pm$ 0.13 mm.

3.3 The average spacing of barbs shall not exceed the specified spacing and no individual spacing shall vary from the specified spacing by more than 19 mm, when measured form the edge of one barb at the strand to the corresponding edge of the adjacent barb.

4 CONSTRUCTION REQUIREMENTS

4.1 The barbed wire shall be formed from two strand galvanized wires complying with the requirements of clause 3 twisted together with an approximate lay of 50 mm, with four point barbs spaced at 100 mm intervals as shown in Fig.1. The barbs shall be wrapped around two strand wires once and round a single strand once, making in all, two turns round the strand wires. The barbs shall be wrapped around the strand wires by a method which prevents slipping to expose the four barbs approximately 90° apart in a plane at right-angles to the strand wire. The point of the barbs shall have a length of 13 ± 3 mm and shall be sharp and cut at an angle not greater than 35° to the axis of the barb.

4.2 The barbs shall be made from 2 mm dia galvanized steel wire complying with the requirements of clause 3.

4.3 Splicing of individual strand wires by means of a wrap joint or an electric butt weld is permitted, before galvanizing. Not more than three joints shall be allowed in one length of wire on the reel.

4.4 Splicing or joints shall be made in a workmanlike manner.

5 GALVANIZING

5.1 The wire shall be hot dip galvanized in accordance with WAPDA specification P-82 "Zinc Coating". The weight of zinc coating shall be 200 gms/sq meter.

6 FINISH

6.1 The zinc coated steel wires shall be clean, smooth and free from harmful defects prior to being stranded.

7 SAMPLING, ACCEPTANCE AND REJECTION

7.1 Each consignment shall be divided into lots containing 50 reels in each lot. A sample of 5 reels shall be drawn at random from each lot.

7.2 The sample shall be subjected to visual examination and verification of dimensions. If the number of defective reels is one, the lot shall be accepted. If the number of defective reels is two, another sample of 5 reels shall be drawn at random and subjected to tests. If the number of defective reels is again two or more, the lot shall be rejected.

7.3 Specimen shall be cut from all the reels selected as per clause 7.1 for galvanizing test and breaking strength and elongation test. If one specimen fails the lot shall be accepted. If the number of failures is more than one, the lot shall be rejected.

8 TESTS

The following tests shall be carried out:

1. Visual examination
2. Verification of Dimensions
3. Galvanizing Test
4. Breaking Strength & Elongation Test

9 TEST METHODS

9.1 Visual Examination

Barbed wire shall be visually examined for defects given below in Table-2.

TABLE-2 VISUAL EXAMINATION

	Examination	Defects
1.	Material	Not as specified
2.	Construction	Strands not uniformly twisted, Barbs not sharp, not tightly wrapped and uniformly spaced as per clause 4.
3.	Finish	Galvanizing not proper

9.2 Verification of Dimensions

The diameter of individual wires shall be measured at four different points on each reel. The measurements shall be within the specified values with the permissible variations given in clause 3.

9.3 Galvanizing Test

The galvanizing test shall be carried out on individual strand wires in accordance with Wapda Specification P-82 "Zinc Coating".

C.4

9.4 Breaking Strength & Elongation Test

The breaking strength & elongation of individual strand wires shall be tested using suitable Tensile Testing Machine.

10 PACKING AND MARKING

10.1 The barbed wire shall be supplied, on wooden reels. The reels shall be made from high quality wood and shall be of sound construction, as such shall be able to withstand the usual rigours of transportation and handling in the field.

10.2 There shall be only one length of barbed wire on each reel.

10.3 The manufacturer shall provide the following markings on the outer side of flanges in a legible and indelible manner.

1. Wapda Specification Number
2. Manufacturer's Name or Trade Mark
3. Serial Number of the Reel
4. Address of the Consignee

10.4 The manufacturer shall stamp the following information on metallic plates which shall be nailed to both sides of the reel.

1. Size of barbed wire
2. Net weight and gross weight in Kg.
3. Serial number of the reel.

10.5 Both sides of the reel shall have an arrow marking indicating the direction of rolling.

Encls: Fig. 1.

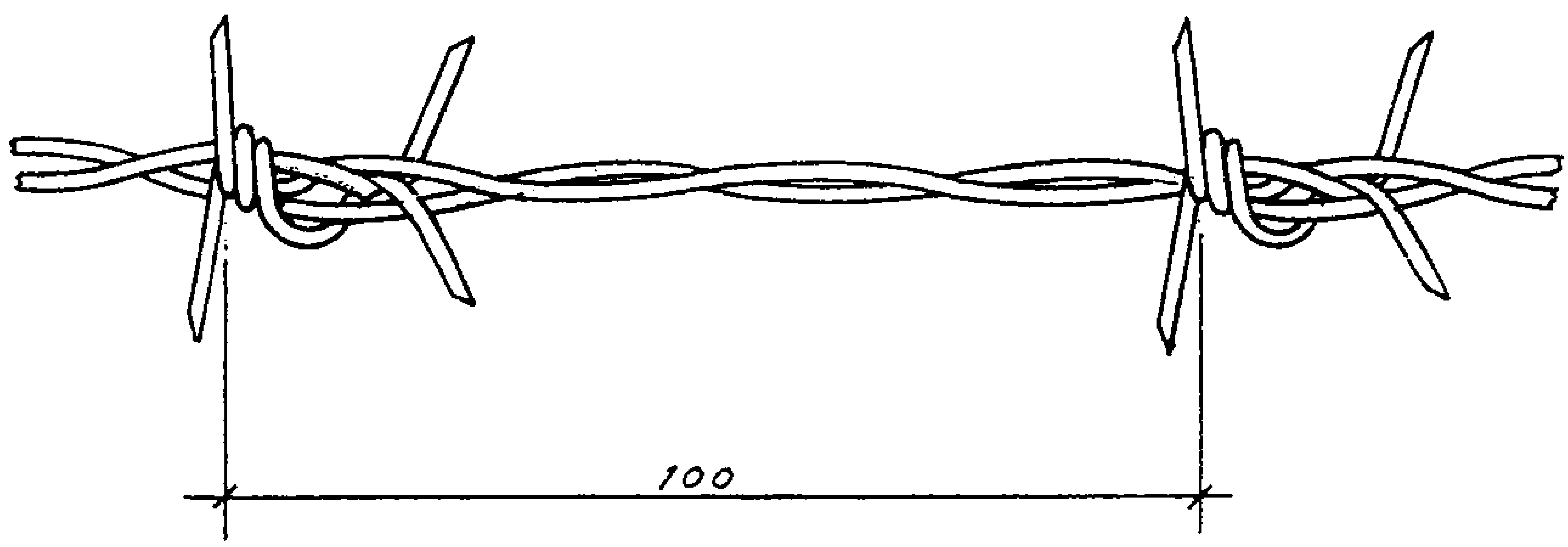


FIG. 1

SPECIFICATION P-104: 76

DANGER AND SIGN PLATES

PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY
DESIGN DEPARTMENT (T&G) POWER

SPECIFICATION P-104: 76

DANGER AND SIGN PLATES

AMENDMENT NO. 1 DATED 12TH DECEMBER, 1981

1. Clause 4.2: a) Delete the following words in 2nd and 3rd line:

" galvanising and thermal shock".

b) Add clause 4.3 after clause 4.2 as under:

"Clause 4.3 Three random smaples of danger, number and phase plates selected from a lot of 1000 units shall be subjected to resistance to thermal shock test. Similarly three random samples of fixtures shall be subjected to galvanising test. If two or more than two units fail to meet the requirements, the entire lot shall be rejected. If one unit fails another group of three samples shall be selected at random from the same lot and above tests repeated. If any sample from the second group fails, the entire lot shall be rejected".

CONTENTS

PRINTING HISTORY

First approved on 24th April, 1976

First amendment on 12th Dec. 1981

DANGER AND SIGN PLATES

0 FOREWORD

0.1 This specification has been prepared by the Standards and Research Directorate of the Design Department (Power) WAPDA, Lahore.

0.2 This specification is intended only for the purpose of procurement of material and does not include the provision of the contract.

0.3 A specification on danger plate was issued in July, 1965 in the form of SDI-33. Then in January, 1972 a product description "PD-127" was issued on this subject.

Now a self-contained detailed specification is being issued under the Wapda Specification series which supersedes the above two publications namely SDI-33 & PD-127.

1 SCOPE

1.1 This specification covers vitreous enamelled danger and sign plates for use on distribution and transmission lines. It also covers the fixture for 11 KV and 33 KV danger plates.

2 CONSTRUCTION REQUIREMENTS AND DESIGN

2.1 *Material*

2.1.1 The danger and sign plates shall be made of high grade sheet steel of thickness 1.5 mm.

2.1.2 The fixture for danger plate for 11 and 33 KV shall be manufactured from mild steel.

2.2 *Vitreous Enamelling*

2.2.1 The danger and sign plates shall be enamelled on both sides and they shall be thoroughly cleaned before enamelling.

2.2.2 The enamel shall be of even thickness, reasonably free from cracks, patches, pin holes, blisters and shall have a uniform gloss.

2.2.3 *Number of Coats of Vitreous Enamel* Three coats of vitreous enamel shall be applied on the danger and number plates. The first coating of black enamel shall be applied on both sides of the plates. The other two coats of white vitreous enamel shall be applied on the front side of the plates only.

In case of phase plates, three coats of vitreous enamel shall be applied. The first coat of the black enamel shall be applied on both sides. The other two coats of red, yellow and blue colour shall be applied as specified on both sides of the plate.

2.2.4 *Lettering* The lettering both of English and Urdu on the danger plates shall be red enamelled and the sizes of the lettering shall be as given in drawing No.PDW/DF-205. The danger symbol shall also be enamelled in red colour and its size shall be as marked on the drawing.

The height of lettering for "Number Plate" shall be 75 mm and the width shall be 25 mm. The letters shall be spaced at 6 mm from each other.

2.3 *Danger Plate*

2.3.1 The danger plate shall be vitreous enamelled and made of high grade sheet steel of 1.5 mm thickness.

2.3.2 The size of the plate shall be 260 x 200 x 1.5 mm and shall be manufactured in according with the drawing No. PDW/DF-205. The holes shall be provided as shown in the drawing.

2.3.3 The danger plates shall be marked with the voltage value i.e. 11000, 33000, 66000, 132000, 220000 and 500000. This marking should appear at the place shown in the drawing.

2.4 *Number Plate*

2.4.1 The number plate shall be of 200 x 150 x 1.5 mm size and shall be made in accordance with the drawing No.PDW/DF-207. Two nos holes shall be provided as shown in the drawing.

2.4.2 The code of the line and the tower number shall be red enamelled and shall be provided as specified. The code and tower number shown on the drawing are only for reference.

2.4.3 The assembly of the number and danger plate to be fixed on the tower has also been shown in drawing No.PDW/DF-207 for reference.

2.5 *Phase Plate*

2.5.1 The phase plate shall be of 115mm diameter with a hole of 12mm diameter as shown in the drawing PDW/DF-207. These plates shall be red, blue and yellow enamelled as specified.

2.6 *Fixture for Danger Plates*

2.6.1 The danger plate fixture is to be supplied only with 11KV & 33 KV danger plates and shall be manufactured in accordance with the dimensions given in drawing No. PDW/DF-206.

2.6.2 The fixture shall be hot dip galvanised in accordance with WAPDA Specification P-82. The average and minimum weight of coating shall be 610 and 550 gm/sq meter respectively. This corresponds to a thickness of 0.086mm and 0.077 mm respectively. The holes shall be drilled before galvanising.

2.6.3 The finish of the fixture shall conform to best commercial practice. The galvanising shall be completely free from lumps, blisters, uncoated or porous spots, black spots, dross, flux or other imperfection.

2.6.4 Four Nos bolts and nuts shall be supplied with each fixture as shown in the drawing in accordance with WAPDA Specification P-19 and plain steel washers shall be supplied in accordance with WAPDA Specification P-20.

2.6.5 Bolts, nuts and washers to be supplied with the fixture shall be electro-galvanised in accordance with WAPDA Specification P-82. The minimum thickness of coating shall be as follows:-

Local thickness	0.025 mm
Average thickness	0.038 mm

3 TESTS

3.1 The following sample tests shall be carried out on the samples selected for testing as per clause 4.

1) Visual examination
2) Verification of dimensions.
3) Galvanising test (on fixture only)
4) Resistance to thermal shock (vitreous enamel finish)

4 SAMPLING, ACCEPTANCE AND REJECTION

4.1 Danger, number, phase plates and fixtures offered for acceptance shall be divided into lots containing upto 1000 units in each lot. A sample of 50 units shall be drawn at random from each lot.

4.2 The selected samples shall be subjected to the visual examination, verification of dimensions, galvanising and thermal shock tests. If the number of defective units is four, the lot shall be accepted. If the number of defective units is more than five the lot shall be rejected. If the number of defective units is five, another sample of 50 units shall be selected at random and subjected to tests. If the number of defective units is again five or more the lot shall be rejected and if the number of defective units is four or less the lot shall be accepted.

5 TEST METHODS

5.1 *Visual Examination*

The plates and fixtures shall be visually examined in the light of the following table:-

TABLE - I VISUAL EXAMINATION

Examination	*Defects*
Construction	*Not of the shape given in drawings. Any crack on the nuts, bolts.*
Material	*Not of proper material.*
Finish	*Galvanising of bolts, nuts, washers and fixture not proper, presence of black spots, blisters, flux, dross, un-coated areas or any other defects. Bolts and nuts, rusty. Threads marred. The plates not properly enamelled, presence of cracks, patches, pin-holes, blisters or any other defect. Letters and numbers broken or not properly enamelled.*
Marking	*Missing or in-complete.*

5.2 *Verification of Dimensions*

Dimensions of the danger, number, phase plates and fixtures shall conform to those given in drawing No. PDW/DF-205, 206 and 207 with allowable tolerances as marked on the individual drawing. Any variation from the specified dimensions shall constitute a defect.

5.3 *Galvanising Test*

The galvanising of the bolts, nuts, washers and fixtures shall be tested in accordance with WAPDA Specification P-82 "Zinc Coatings". The weight/thickness of coating shall conform to the values given in clause 2.6.2 & 2.6.5.

5.4 *Resistance to Thermal Shock*

This test shall be carried out by subjecting the test specimen to radiant heat so as to reach a steady temperature of 185 - 195°C in about ten minutes. The temperature shall be measured by means of a surface pyrometer in contact with the top surface of the heated part of the specimen.

Remove the radiant heat and within 5 seconds quench the surface with 1000 ml of water at 15-20°C direct from an aspriator or other container through a 5 mm diameter tube, the end of the tube being 150 mm above the centre of the heated portion of the test specimen. The flow rate of water shall be adjusted to 10 ml per second. It is convenient to mark the test area to ensure that the water is correctly applied. Dry the plate, replace in the same position under radiant heat source and repeat this procedure until six cycles have been completed.

Assessment of Results. After subjecting the test specimen to the above test, the vitreous enamel surface shall be considered to be resistant to thermal shock provided that the enamel shows no signs of flaking-off or crazing.

6 MARKING AND PACKING

6.1 *Danger plates & number plates for 66 KV lines and above*

The danger plates and number plates shall be packed in strong wooden boxes containing 100 plates in each box. The packing shall be strong enough to withstand the rigours of transportation by rail or road.

6.2 *Danger plates & fixtures for 11 & 33 KV plates*

The danger plate/fixture shall be packed in strong wooden boxes with 100 plates/fixtures in each box. The packing shall be strong enough to withstand the rigours of transportation by rail or road.

6.3 *Phase Plates*

The phase plates shall be packed in strong wooden boxes. Each box shall contain 200 phase plates. The packing shall be strong enough to withstand the rigours of transportation by rail or road.

6.4 The packing box shall carry the following markings:

(1) *Wapda Specification number*

(2) *Product Description with voltage rating in case of danger plates*

(3) *Manufacturers' name or trade mark*

(4) *Number of items in the box*

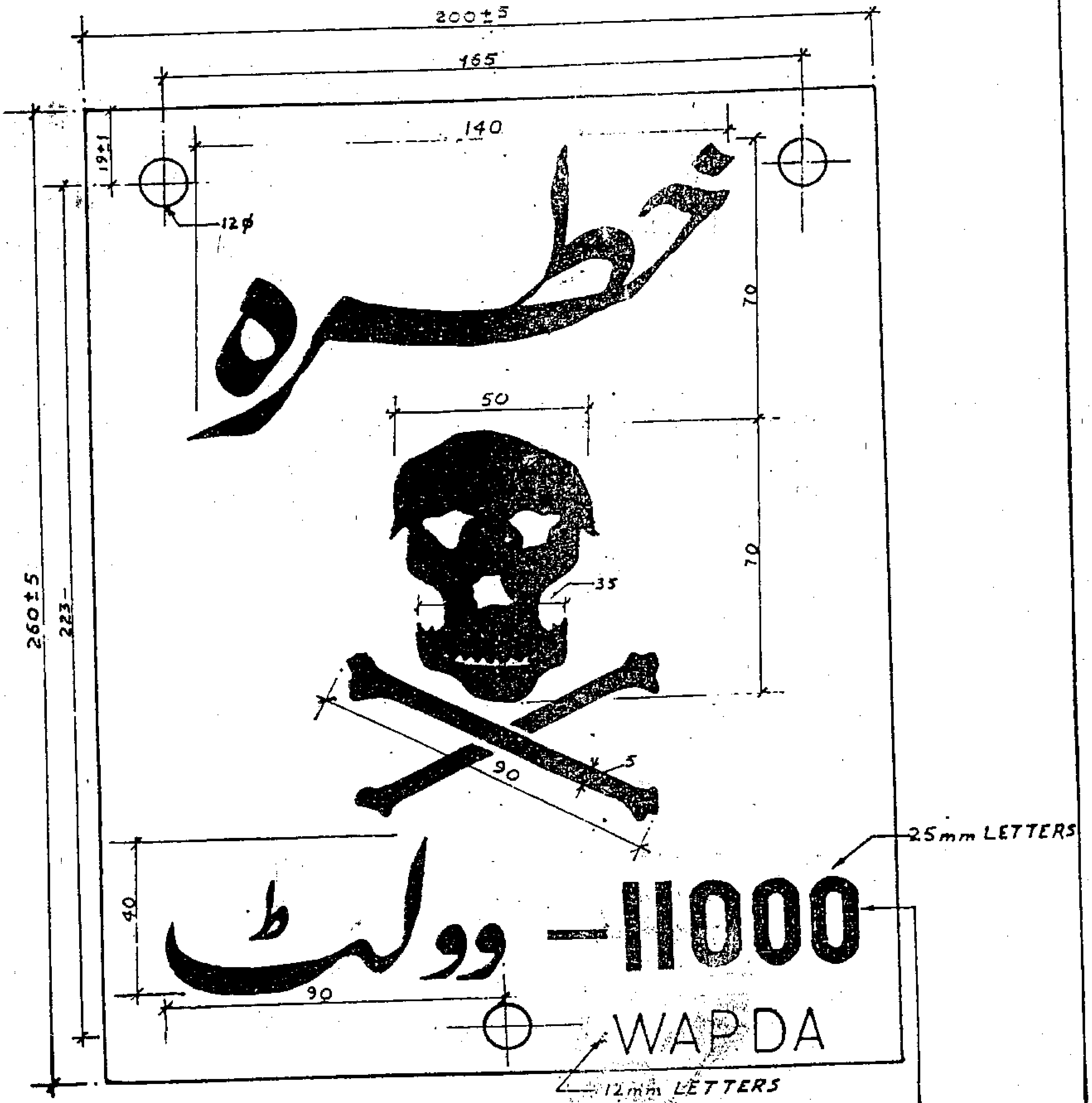
(5) *Gross weight in kg*

(6) *Address of consignee.*

6.5 *Marking*

6.5.1 The plates shall be marked clearly and idelibly with the wording "WAPDA" in red enamel as shown on the individual drawing in case of danger and number plates. This marking shall be white enamelled in case of red, yellow and blue phase plates. The wording "WAPDA" shall be punched on the fixture. The size of lettering shall be 12 mm in each case.

Encls: Drawing No. PDW/DF-205
PDW/DF-206
PDW/DF-207

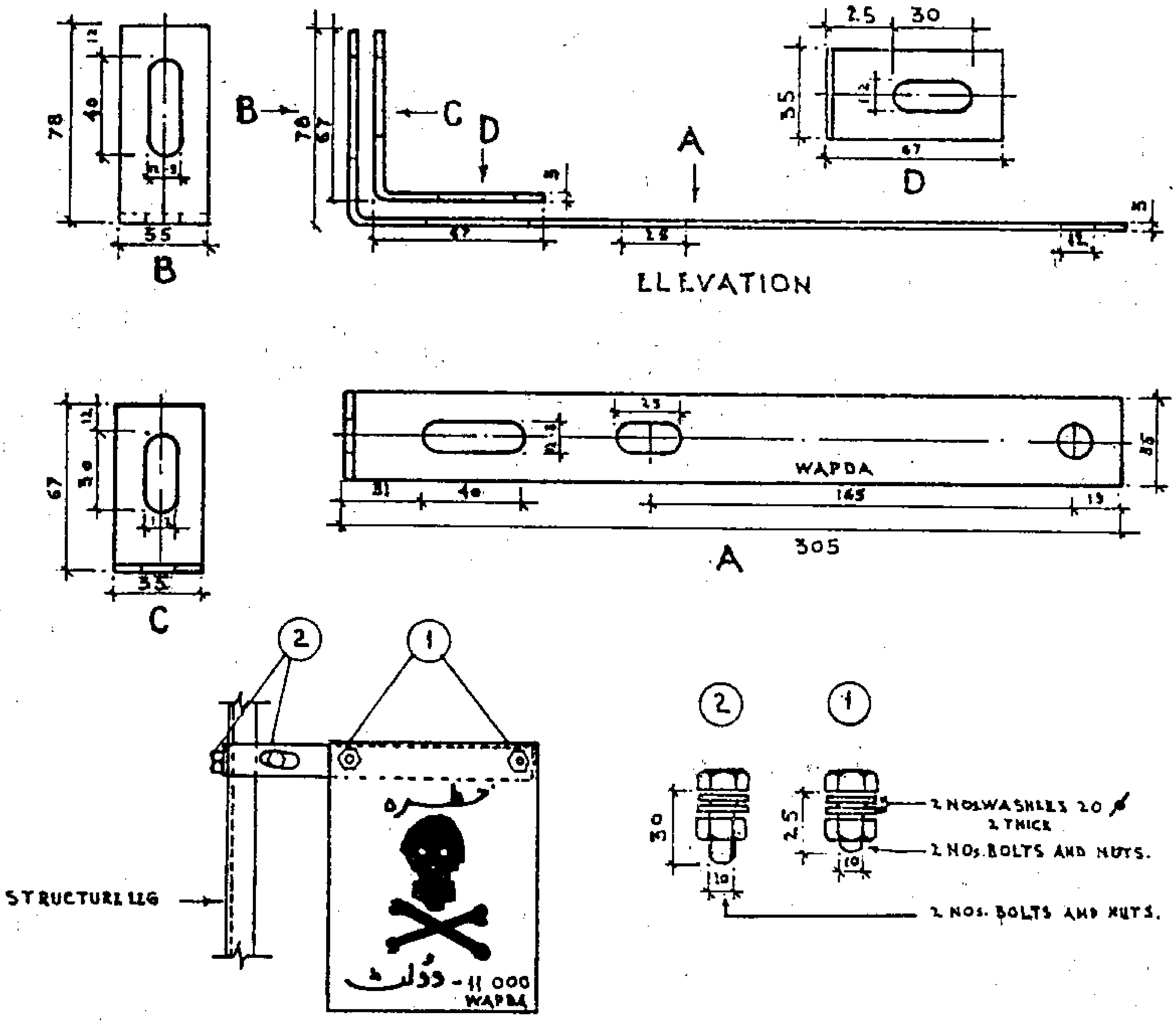


THE OTHER VALUES OF VOLTAGE(33,000 TO 500,000) TO BE GIVEN HERE.

MATERIAL : HIGH GRADE SHEET STEEL
THICKNESS OF PLATE : 1·5 mm
LETTERS : RED ENAMELLED
SYMBOL : RED ENAMELLED
GROUND : WHITE ENAMELLED
BACK SIDE : BLACK ENAMELLED

ALL DIMENSIONS IN MILLIMETRES

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY			DESIGN DEPARTMENT (POWER)
DANGER PLATE FOR DISTRIBUTION AND TRANSMISSION LINES			
DWN	A.E	SCALE —	DATE 19.4.76
TCD	A.D	DWG. NO. PDW/DF_205	
CKD	DIR		

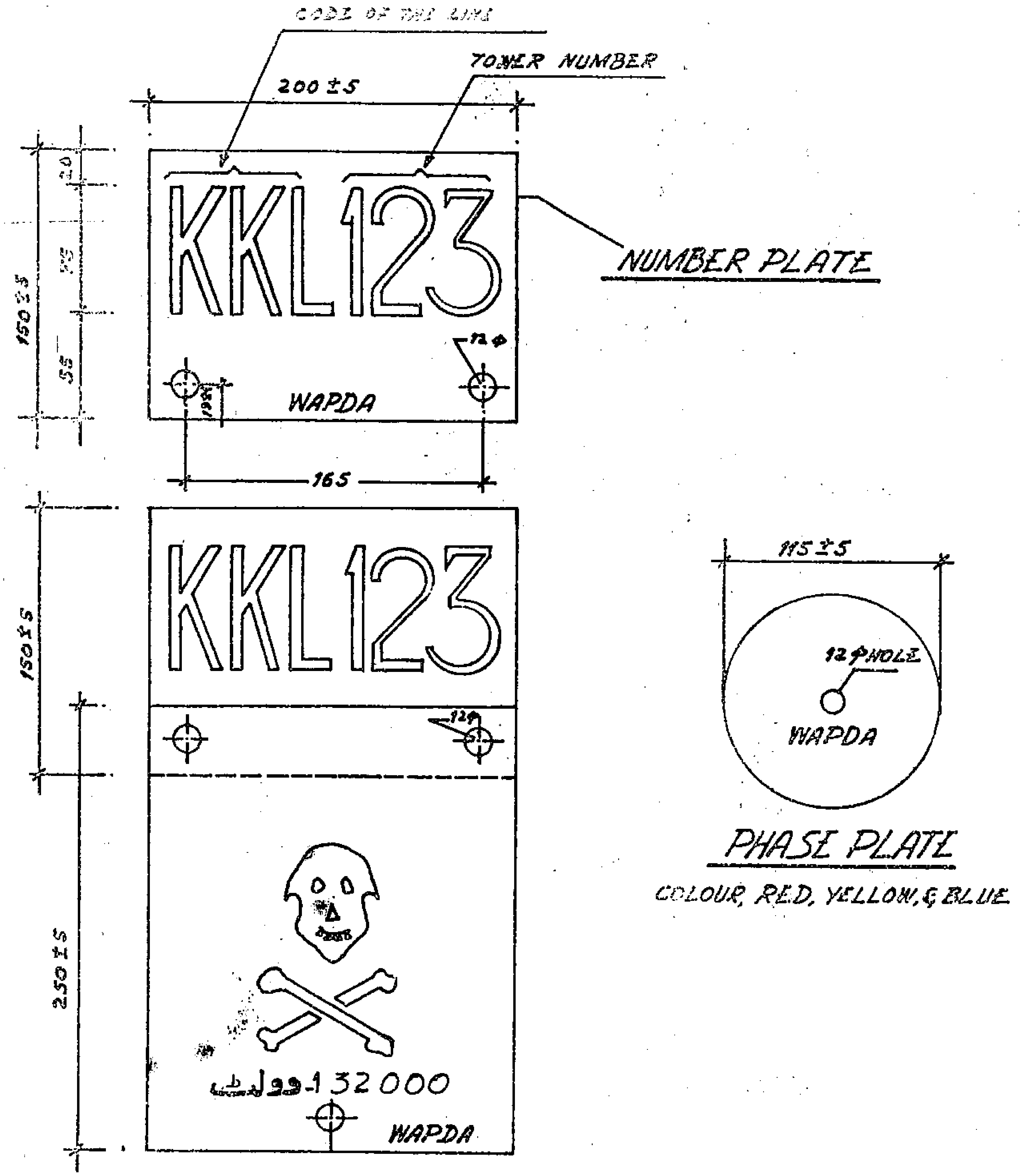


ASSEMBLY
FOR
11,000 & 33,000 VOLTS DANGER PLATE

ALLOWABLE TOLERANCE 5%
ON EACH DIMENSION

ALL DIMENSIONS IN MILLIMETRES

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY			DESIGN DEPARTMENT POWER
FIXTURE & ASSEMBLY FOR 11 KV AND 33 KV DANGER PLATE			
DWN.	A.E.	SCALE.-	DATE:- 19.4.76
TCR Ashgar Iqbal	Sadiq Qureshi XEN	DWG. NO. PDW/DF-206	
CKD.	DIR.		



ASSEMBLY OF NUMBER &
DANGER PLATE OF TRANSMI-
-SSION LINE.

ALL DIMENSIONS IN MILLIMETRES.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY			DESIGN DEPTT: POWER
NUMBER PLATE & PHASE PLATE FOR TRANSMISSION LINES.			
TCD. Hussain	A.E.	SCALE:-	DATE:- 19-4-76
DWN.	Sadiq Qureshi D.D.	DWG NO. PDW/DF-207	
CKD.	DIR.		

SPECIFICATION P-20: 68
(UDC 621.882.4)

PLAIN STEEL WASHERS

PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY
DESIGN DEPARTMENT (P)

SPECIFICATION P-106: 83

STEEL POLES FOR TRANSMISSION LINES

PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY

SPECIFICATION P-166:83

STEEL POLES FOR TRANSMISSION LINES

AMENDMENT NO.1 DATED 9TH DECEMBER 2013

1. **Clause 8.4.3**

   Add the following lines at the end of clause 8.4.3

   "The Suspension or Tension String Assembly shall be attached with the cross arm through the Shackle Drawing No.PDW/DF-478.

2. Add after Clause 10.10 under the heading of the Enclosure at Sr.No.9 the drawing No.PDW/DF-478.

9.01.14

(ISHFAQ-UL-MAJEED)
ADDL. MANAGER DESIGN (T/L)

(ABDUR RAZZAQ CHEEMA)
CHIEF ENGINEER DESIGN (NTDC)

C O N T E N T S

PRINTING HISTORY

First approved January, 1983.

SPECIFICATION P-166: 83

STEEL POLES FOR TRANSMISSION LINES

0 FOREWORD

0.1 This standard has been introduced by WAPDA and has been prepared by the Transmission Line Section of the office of the Chief Engineer (Designs).

0.2 This standard is intended only for the purpose of Technical Specification to facilitate design and fabrication of steel poles for Transmission Lines and does not include provisions of Contract.

0.3 This Specification is based on International Electrotechnical Commission document no 11(CO)10 Recommendation for over head lines, July 1980 fordetermination of wind load and ASCE method of Design of Steel Transmission pole structure for analysis.

1 SCOPE

1.1 This Specification covers the design, fabrication and supply of galvanized steel poles for Transmission Lines.

2 DEFINITIONS

2.1 Conductor

A conductor is a wire meant to transmit electrical energy or an overhead ground wire for lightning protection and induction in telephone line.

2.2 Span

Span means the horizontal distance between the two adjacent poles of a Transmission Line.

2.3 Wind Span

The wind span is half the sum of the two spans adjacent to a pole.

2.4 Weight Span

Weight span is the horizontal distance between the low points of sag in the two spans adjacent to a pole under minimum temperature conditions.

2.5 Longitudinal

The horizontal direction along the run of conductors of a transmission line and parallel to its centre line. At angle locations it is the direction bisecting the external angle between the two adjacent sections of the transmission lines.

2.6 Transverse

The horizontal direction at right angles to the run of conductors of a transmission line. At angle locations it is the direction bisecting the internal angle between the two adjacent sections of the Transmission line.

3 TYPES OF POLES

3.1 The Transmission lines poles shall consist of a galvanized steel pole with six crossarms and shall be of embedded or anchor base foundation type. The pole and crossarm shall be circular or polygonal in shape, and tapered uniformily. The poles shall be in several sections and assembly of sections shall be achieved by slip joints.

3.2 The poles are of following types:

i) Type SP-A Tangent Pole 0^{0} - 2^{0} Angle

ii) Type SP-D Medium Angle 2^{0} - 30^{0} Angle

iii) Type SP-G Heavy Angle 30^{0} - 60^{0} Angle and dead end.

The poles are designated by the code numbers. These codes have been assigned in the following manner:

a) The first two letter 'SP' stands for steel pole for Transmission Lines.

b) The succeeding letter A, D & G denotes the angle, these poles can sustain.

3.3 Double Circuit Steel Pole Type SP-A

Double circuit suspension pole for straight line position and angles upto two degrees for a wind span of 180m, a weight span of 225m.

3.4 30 Degree Double Circuit Steel Pole Type SP-D

Double circuit strain pole for line angles upto 30 degrees on a wind span of 180m, a weight span of 225m.

3.5 60 Degrees Double Circuit Steel Pole Type SP-G

Double circuit strain pole for line angles upto 60 degrees on a wind span of 180m, a weight span of 225m. This pole shall also be capable of acting as a dead end pole with all conductors strung at right angles to crossarm axis on one side only at their maximum loaded tension.

4 LOADINGS

4.1 Each type of pole shall be designed to safely withstand the loading due to wind on pole, conductors, hardware, earthwire and dead weight of pole and fittings, due to resultant transverse load at angles as indicated hereaftor.

4.2 Maximum wind velocity (VM) has been taken as 45m/Sec and the Reference wind velocity (VR) as 30.2m/Sec taking into account ground roughness coeffecient as 0.67. The magnitude of wind load on pole and wires is a pressure of 57 Kg/m^2.

4.3 Wind On Pole

4.3.1 In order to determine the effect of the wind on the pole itself the latter shall be divided into elements of suitable height. The ultimate wind load in the transverse direction applied at the centre of gravity of an element shall be:

$A_{TC} = qo.\ C_{XTC}.G_T.d\ .\ L.$

qo = dynamic Reference pressure = $57 Kg/m^2$

d = Diameter of the pole

L = Length of the element

G_T = Gust response factor = $2.22(Z_T)^{0.175}$

Where Z_T = Height from centre of gravity of element above ground.

4.3.2 Drag coefficient C_{XTC} shall be calculated in terms of Reynolds nos. which shall be equal to:

$R = 20.8x10^5 xd/\sqrt{G_T}$

Where d = diameter of pole

$CXTC = 1.2$ for $R \leqslant 3x10^5$

$CXTC = 0.75$ for $R \geqslant 4.5x10^5$

For values of Reynold's nos between $3x10^5$ and $4.5x10^5$, the value of C_{XTC} may be determined by:

$C_{XTC} = 15.195-2.555 \log R$

4.4 Ultimate Loads

4.4.1 Tranverse, longitudinal and vertical loads on the pole body shall be applied uniformly along the pole.

4.4.2 The load on conductors and insulators shall be assumed to act at the conductor attachment points.

4.4.3 The ultimate loads for all types of poles are given in Table-I.

4.4.4 Stringing conditions are mainly meant for design of crossarms. It shall be assumed that only two conductors shall be strung simultaneously and the Angle between the Anchorge and ground shall not be more than 15°.

TABLE - I

ULTIMATE LOADS ON POLES

(All Loads in Kg)

Sr. No.	Type of Load	Pole Type SP-A	Pole Type SP-D		Pole Type SP-G
	A: Transverse Loads		30°	60°	Dead End
A1	Wind on Earthwire and fittings with E/wire intact.	260	260	260	260
A2	Due to line angle on E/wire with E/wire intact.	26	380	732	-
A3	Wind on conductor, insulators & fittings with conductor intact.	860	935	935	935
A4	Due to line angle on conductors with conductor intact.	90	1330	2568	-
	B: Vertical Loads				
B1	Weight of E/wire and fittings for intact E/wire.	120	120	120	120
B2	Weight of conductor, insulator strings & fittings for intact conductor.	650	720	720	720
B3	Weight of E/wire and fittings for stringing condition.	275	275	275	275
B4	Weight of conductor and fittings for stringing condition.	1175	1175	1175	1175

Sr. No.	Type of Load	Pole Type SP-A	Pole Type SP-D		Pole Type SP-G
			30^{o}	60^{o}	Dead End
B5	Dead weight of pole	-	-	-	-
	C: Longitudinal Loads				
C1	Due to dead-ending of intact Earth Wire.	-	-	-	735
C2	Due to dead-ending of intact conductor.	-	-	-	2570
C3	Due to stringing condition for Earth Wire.	580	580	580	
C4	Due to stringing condition for conductor.	1947	1947	1947	
C5	Wind on Pole	(Refer to clause 4.2)			

4.5 Each pole shall be designed to withstand all combinations of vertical, transverse and longitudinal ultimate loads arising from the loading cases stated below and the conditions stated in clause 4.3. The combination and direction of loads shall be such as to induce maximu stresses in elements. In all cases the Pole shall be assumed loaded with full wind and weight spans and full line angles.

Case 1 It shall be assumed that all conductors are installed and intact, the wind shall be assumed to blow in the transverse direction.

Case 2 Three wires installed on one circuit and wind shall be assumed to blow in Transverse direction.

Case 3 Stringing Condition. (Two conductor shall be string simultaneously)

5 DESIGN REQUIREMENT

5.1 <u>General</u>

5.1.1 Each Pole shall be of self supporting with embedded anchor base foundations and shall be able to carry the loads and meet the loading conditions of this specification.

5.1.2 The general configuration and dimensions of poles and clearance shall be as per attached drawings. The diameters of poles shall not exceed the max values shown. Section lengths shall not exceed 12 meter. The min thick ness of material used for poles shall be 6 mm and for crossarm shall be 4 mm.

5.1.3 The Contractor shall be fully responsible for the design of the poles and for their satisfactory performance. All designs furnished by the Contractor and approved by the Engineer shall be considered a part of this specification

5.1.4 All designs and drawings submitted by the Contractor shal become the property of WAPDA. The WAPDA expressely reserv the right to use, reproduce in while or in part to distri bute, and to reuse any and all such drawings in connectio with the installation, maintenance, replacement and repai of the materials to be furnished under the specification and also to make any and all such drawings and reproductions thereof available to subsequent Tenders and Contrac tors, where necessary in connection with fabricating and furnishing materials duplicating or closely similar to the materials to be furnished hereunder. The depositing of all such drawing with the Engineer shall constitute a licence to the WAPDA to use said drawings in the manner herein stated.

5.2 Design Methods

5.2.1 All calculations for determining allowable stresses on pole shall be according to ASCE Methods "Design of Steel Transmission Pole Structures".

5.2.2 All calculations carried out on computer shall be accompanied by a full explanation of the computer programmes and the methods used in the calculations.

5.2.3 As the poles are of cantilever type, consideration shall be given to the most unfavourable condition of simple buckling or combined buckling by bending and torsion.

5.2.4 Connection between the various parts to be achieved by slip joints, the overlapping length shall be at least equal to 1.5 times the Inside diameter of the female section.

5.2.5 In case of anchor base type poles the dimension and thickness of base plate as well as number, diameter and length of anchor bolts shall be determined by calculations and shall be selected from the range of some International Standard.

5.3 Foundations

5.3.1 The foundations shall be designed on the following basis.

5.3.2 The foundation shall be able to withstand the ultimate forces tension, compression shear and uplift for the worst possible combination of ultimate loads given in clause 4. However for angle poles the ultimate loads shall be multiplied by an additional factor of 1.2.

5.3.3 For design purposes the weight of concrete may be taken as 2300 Kg/m^3 and of earth as 1600 Kg/m^3.

5.3.4 The foundation shall be designed for soil bearing pressure of 2,1, 0.5 Kg/Sqcm.

6 MATERIAL

6.1 Poles shall be made of low alloy high tensile steel sheet or plate having the tensile properties as specified. The steel shall be made by open hearth, basic oxygen or Electric furnace process.

6.1.1 The manufacturer may propose steel conforming to latest applicable Industry Standards Specification and recommendation practices provided such steel has the minimum yield point and minimum Elongation as specified. The manufacturer shall indicate the grade of steel and identify the standard to which the steel complies. The specification of steel shall be approved by Wapda. The following information shall be supplied by the Manufact

Ultimate Tensile Strength

Minimum Guaranteed Yield Strength

Minimum Elongation

Detail of Test Piece

Chemical Composition

6.2 Tensile Properties

The steels shall conform to the requirements as to tensi properties prescribed below:

Yield point kg/mm^2	
Minimum	30 - 40
Elongation in 50mm guage length percent, minimum upto 5mm thickness	16
Elongation in 200mm guage length percent, minimum.	
5mm to 16mm thickness	13
Over 16mm thickness	17

6.3 Bend Test Requirement

6.3.1 The steels shall withstand the following Bend Test Requi ments.

Thickness of Material	Ratio of bend diameter to thickness for specimen
For all thickness	2

6.4 Tolerances

6.4.1 The tolerance of Steel grade and Specification quoted by the Contractor shall be applicable.

6.4.2 Tolerances in the manufacturer of the poles shall be as follows:

i) Overall length of pole $\pm$ 10%

ii) Outside dia $\pm$ 1%

iii) Tube thickness - 8%

iv) Twisting 1.5 Degree per 3m

v) Weight $\pm$ 3%.

6.4.3 The poles shall be straight within 1/300 of length.

7 FABRICATION

7.1.1 All type of poles shall be made of one or several sections or elements tapered uniformly starting with the base or butt end, decreasing in diameter at a suitable rate. In the case of poles made of several sections their assembly shall be achieved by slip joint or flanges.

7.1.2 Poles and crossarms shall have no transverse joints or welds and only one longitudinal weld per thickness of pole shall be permissible.

7.1.3 The upper part of the pole shall be made to accomodate cross-arm of the dimensions and clearances shown on the drawing, necessary for the attachment of conductor and shall be made to match aesthetics of the pole. Crossarms connection to the pole shall be made by flanges.

7.1.4 In case of anchor base type poles the lower part shall be equipped with a base plate to be anchored on a concrete foundation by means of anchor bolts.

7.1.5 The anchor base shall be of sufficient cross section to develop the full strength of the pole by means of two transverse. Electric welds. The base shall telescope the pole and one weld shall be on the inside of the base at the end of the pole and other weld on the outside at the top of the base.

7.1.6 Anchor bolts shall be of suitable diameter and length to develop full the ultimate strength of the pole. The upper ends of anchor bolt shall be threaded and furnished with hexagonal heads. The lower end of the bolt shall have 'L' bend of length not less than 3 times the diameter of bolt. The anchor bolts and nuts shall be hot dip galvanized to WAPDA Specification P-82 Metal covers shall be provided for covering the nuts and the portion of the bolt extending about the base and metal cover shall be attached to the steel base by means of cap screws.

7.1.7 A ground sleeve shall be attached to each embedded type pole. The sleeve shall be made from one piece of sheet or plate. The thickness of the ground sleeves shall be not less than 6mm. The one longitudinal weld shall be ground or rolled smooth. Unless otherwise specified, the sleeves shall be 600mm. The top of the sleeves shall be welded to the pole by means of a fillet weld, which shall be sufficiently beveled to shed water and make joint watertight.

7.2 Welding

7.2.1 All welds shall be performed in works before galvanizing. All welding shall be Electric Arc according to some International Standards and shall include the following processes:

- Shielded metal Arc welding
- Submerged Arc welding
- Gas metal Arc welding

7.2.1.1 The electrodes used shall be compatiable with grade and chemical composition of the steel used and shall have mechanical properties at least equal to physical properties of the steel to be welded. Uncoated electrodes shal be used.

7.2.2 The welds shall conform to the following minimum requirements.

7.2.2.1 Longitudinal Welds l.c. (For poles and Crossarms)

- 90% penetration of all thickness of sheet steel
- The wold shall be free from any inside and outside cracks.
- No blow holes on the surface of the weld shall be allowed.
- No surface blister shall be tolerated.

7.2.2.2 Transverse Weld l.c. (For Base Plate)

- 100% penetration between sheet steels regardless of thickness considerations.
- all welds shall be free from all cracks both inside and outside.
- no blow holes on the outside of the weld.
- the blisters, porosites, spherical inclusions exceeding 5% of the minimum thickness of the sheet steel shall be refused.
- the detectible angular inclusions shall not be tolerated.

7.2.3 In order to maintain the quality of the weld manufacturer shall make use of the most adequate method and control instruments in order to verify the quality of completed weld: ultra sonic or radio control methods (X or gamma rays) shall be used in the works.

7.3 Galvanizing

7.3.1 All parts of the poles and crossarms shall be hot dip galvanized after completion of manufacturing operations. No further manufacturing, touching up or modification shall be performed on the pole or crossarms after they have been galvanized.

7.3.2 The galvanizing shall be performed on both inside and Outside faces of pole and crossarms.

7.3.3 The galvanizing of the relevant plate or sheet of steel used for the manufacturing of pole or crossarms and Nuts and Bolts shall be as per WAPDA Specification P-82.

8 ACCESSORIES

8.1 Sign Plates

All poles shall be fitted with Danger, number and phase plates in accordance with drawing No.PDW/DF-207 The plates shall be fixed in accordance with Drawing No. PDW/DF-207. The sign plates shall be fired ceramic surfaces on steel base plates the ceramic enamel shall completely cover the front and back of the interior edges of the attachment holes the enamel around the hole shall be protected by means of fibre washers.

8.2 Step Bolts

Removeable step bolts of 16mm dia and 130mm step shall be provided in a staggered manner, every 450mm on the pole above anticlimbing devices.

8.3 Anticlimbing Device

The anticlimbing device shall consist of an arrangement of barbed wire around the pole to prevent un-Authorised persons from climbing the pole. It shall be made according to drawing No. GW/TZ-7 the outer most barbed wire shall be at least 600mm from the pole spacing of barbed wire shall not exceed 150mm. The Anticlimbing device shall be fixed at about 3M from ground level.

8.4 Details for Attachment

8.4.1 Provision shall be made for attachment of suspension and tension strings, overhead ground wire and the grounding Rods.

8.4.2 For attachment of ground wire, arrangement shall be made at the top for suspension and tension fittings for 9mm E/Wire to accept assemblies as per drawing No. PDW/DF-319.

8.4.3 For attachment of suspension or tension strings provision in the crossarm shall be made to accept assemblies as per drawing Nos. PDW/DF-314 & PDW/DF-327.

8.4.4 For attachment of ground rods the embed part of the pole shall be provided with a threaded socket for 16mm dia stud of adequate length for attaching the grounding terminal.

8.4.5 In case of Anchor Base type poles. The grounding rods shall be attached to one of the Anchor bolts by means of a copper cable of suitable length as shown on drawing No. EW/TC-42.

8.4.6 All ferrous hardware shall be hot dip galvanized as per WAPDA Specification P-82.

9 TESTS

9.1 Manufacturer Tests

9.1.1 The manufacturer shall select two samples from each heat to carryout the following tests to satisfy himself that the products comply with this Specification. The Tests shall be performed as per WAPDA Specification P-139:80.

For Steel

1. Chemical Analysis
2. Tensile Tests
3. Bend Tests

For Nuts Bolts and Washers

1. Tensile Strength Test
2. Bend Test

The manufacturer shall maintain a record of tests carried out by him for examination by Inspector.

9.2 Acceptance Tests

The following acceptance tests shall be carried out.

For Pole

1. Visual Examination

2. Verification of Dimensions and Weights
3. Prototype Test

For Nuts Bolts and Washers

1.	Verification of Dimensions	(As per
2.	Visual Inspection	(WAPDA
		(Specification
3.	Proof Load Test	(P-139
4.	Ultimate Tensile Strength Test	
5.	Galvanizing Test	
6.	Bend Test	

9.3 Visual Examination

The test samples shall be examined visually for the following:

Visual Examination

Examination	Defects
Material	Not as specified in relevant clauses.
Construction	Not of the shape indicated.
Finish	Galvanizing not proper, presence of burrs, black and bare spots, dross and projection.
Welding	Not as specified

9.4 Verification of Dimensions and Weight

For confirmity to the requirement of dimensions and weight, in case the rejection number increases as specified in this specification, for the limits of tolerances mentioned in clause 6.4.2. The entire lit shall be rejected.

9.5 Prototype Test

This test will be carried out in accordance with clause 9.6 of this specification.

9.6 Prototype Test

9.6.1 Full scale tests shall be carried out on each type of pole of maximum height as shown on the drawings. Different cases are to be tested to the ultimate design loads without failure. The pole shall then be tested to destruction. Load cases shall be specified by the Engineer at a later stage.

9.6.2 The pole shall be erected on a foundation structure or Anchored on Bolts which shall be of adequate strength and stiffness to withstand safely the pole reactions under test loadings without any mobility. The foundation structure or Anchor Bolt arrangement should be such that as simulating the conditions which will be encountered in service.

9.6.3 Each part of the pole and crossarm shall be of the same grade and class as those to be furnished for the specified poles of the same type.

9.6.4 The poles to be tested shall be galvanized and in all respects identical to the poles to the supplied.

9.6.5 The testing Bench shall be so designed as to prevent practically any introduction of appreciable error in measurement such as frictions. For that purpose the measuring device used shall be placed in such a manner as to directly record the loads.

9.6.6 Prior to testing, the contractor shall submit for approval of the Engineer a line diagram showing layout of the test site, rigging, location of load measuring instruments to be used and a series of line diagrams showing the loads to be applied, taking into account the weight of rigging and angle of load application. The contractor shall submit for approval a tabulated form on which the applied load and corresponding deflection readings will be entered for each load case.

9.6.7 Testing Bench at the test site shall be capable of handling ultimate loads with safety. Testing Bench shall be capable of handling increased loads during destruction testing with adequate safety of personnel working on the test facility.

9.6.8 The load monitoring equipment shall be electronic transducers complete with appropriate digital readout meters and recorders with an overall accuracy $\pm$ 1%. All load monitoring equipment shall be calibrated before and after testing of the poles.

9.6.9 The testing of pole shall be carried out in the pressence of personnel of the Engineer.

9.6.10 WAPDA shall be notified at least six weeks in advance of the date the tests are to be conducted. Time shall be allowed for the Engineer to approve the actual.

9.6.11 The ultimate loads shall be applied. The drawing showing the combination of loads for testing shall be supplied by the Engineer at a later stage. The loads shall be applied in five steps of 50%, 75%, 90%, 95% and 100% of the ultimate loads. Each test loading shall be applied according to the drawings and maintained for not less than 5 minutes during which time there shall be no slacking of or adjustment of the loads. Should it become necessary to adjust the loading, the 5 minutes period shall start after the loading, is stablized and constant. All test loads shall be removed completely before the loads for the next test are applied. After each test load deformation due to longitudnal, transverse torque strain shall be measured (A 10% deformation residue of the maximum deformation recorded at the end of the pole due to the adjustment of the parts and to the remaining tension in the hoisting cables will be acceptable). All test loads corresponding to conductor and ground wire loading shall be applied directly to the regular attachement detailed provided for these loads. Test load equivalent to wind load on the pole shall be applied at the Centre of Gravity of the specified section of element, taking into account the drag coefficient as calculated according to clause 4.1 of this specification. To ensure application of full test loads to the pole, friction losses in rigging shall be added to specified loads, if there is rigging between the pole and the load measuring device. Application of impact loads shall be avoided.

9.6.12 Any conspicuous yielding or any failure under any of the above test loadings shall be considered a defect. If a defect develops because of faulty workmanship or materials, the contractor shall correct the defect and repeat the test loading at his own expense, including any additional cost incurred by WAPDA for the witnessing of the repeat test loading by the Engineer.

9.6.13 In the event of collapse of part under loads of a value lower than 95% of ultimate loads, the part that has collapsed may be replaced by another with greater mechanical strength. The modified structure shall be required to pass the test for the specified 100% ultimate load.

9.6.14 If the collapse of a part occurs at loads between those corresponding to the 95% and 100% of the ultimate loads, one of the following two procedures may be adopted:

a) The poles shall be tested according to the procedures as mentioned in clause 9.6.13.

b) The test shall be repeated on another pole of the same batch and the structure shall be required to pass the 100% of the ultimate load as specified by the Engineer.

9.7 Sampling Plan-Acceptance and Rejection

Sampling sizes are designated by code letters. Table-III shall be used to find the applicable code letter for the particular lot or batch size for various tests specified in this specification. While the number of units of product from each lot or batch which are to be inspected (sample size) and the criteria for determining the acceptability of the lot or batch (acceptance and rejection numbers) for different code letters can be obtained from the Table-V given below

The number of sample units inspected shall be equal to the first sample size given in Table-V. If the number of defective units found in the first sample is equal to or less than the first acceptance number, the lot shall be acceptable. If the number of defectives found in the first sample is equal to or greater than the first rejection number, the lot shall be rejected. If the number of defectives found in the first sample is between the first acceptance and rejection number, second sample of the size given by the plan shall be inspected. The No. of defectives found in the first and the second samples shall be accumulated. If the cumulative No. of defectives is equal to or less than the second acceptance number the lot shall be acceptable. If the cumulative No. of defectives is equal to or greater than the second rejection number, the lot shall be rejected.

TABLE-V SAMPLE SIZE

Lot or Batch Size	Sample size for test specified in clause 9.6	Sample size for dimensional and finish defecte
2 to 8	A	A
9 to 15	A	B
16 to 25	A	C
26 to 50	A	D
51 to 90	B	E
91 to 150	B	F
151 to 280	B	G
281 to 500	C	H
501 to 1000	D	J

TABLE - V SAMPLE ACCEPTANCE CRITERIA

Sample size code letters	Sample	Sample Size	Cumulative sample size	Acceptance Number	Rejection Number
A	First	1	1	0	1
	Second	-	-	-	-
B	First	2	2	0	2
	Second	2	4	1	2
C	First	3	3	0	2
	Second	3	6	1	2
D	First	5	5	0	2
	Second	5	10	1	2
E	First	8	8	0	2
	Second	8	16	1	2
F	First	13	13	0	3
	Second	13	26	3	4
G	First	20	20	1	4
	Second	20	40	4	5
H	First	32	32	2	5
	Second	32	64	6	7
J	First	50	50	3	7
	Second	50	100	8	9

10 DRAWINGS AND DATA

10.1 The Contractor shall submit outline drawings and design drawings of steel poles as indicated in clauses 10.2 to 10.6 with his bid. After placing of the Contact the Contractor shall submit for approval, drawings as indicated in paras 10.7 to 10.10 and any other calculations and drawings required by the Engineer.

10.2 The following information shall be supplied:

i) Catalogues/Literature of Standardised item.

ii) Test Certificate

iii) Detail of manufacturing welding and testing facilities available with manufactures.

10.3 Material Details

Information such as grade and standard of steel used giving ultimate tensile strength, min Elongation, min yield strength chemical composition of steel, standard & method galvanizing & welding and method of fabrication of pole shall also be appended. English language copy of the particular standard according to which the steel is supplied, and the standard for all galvanizing, welding and other applicable steel shall be supplied with bid.

10.4 Outline Drawings

Outline drawings for each type of pole and showing the size, location and arrangement of all elements principal outline dimensions and conductor clearances to the poles, the size and length of elements shall be provided. It should be possible to verify the drag coefficient and weight of poles. Separate details to a large scale shall be shown for all insulator and ground wire connection. If necessary for clarification, a large scale shall also be used for plotting details.

10.5 Design Calculations and Stress Diagrams

Design calculations and stress diagrams shall show the following information. Detailed calculations of wind loadings on pole shall be included. Loading calculations Bending Moments, stress diagrams, Sectionmodulus, Thick-- nesses, Inside & Outside diameter for each section or Elements of pole.

Design calculations if carried out by computer shall be fully documented. Full details of the analytical methods used shall be provided. Documentations shall provide a full explanation of the methods of programming and the interpretation of the detailed results.

10.6 Foundation Drawings and Calculations

Fully dimensioned drawings of all foundations showing als the volume of the foundations. Calculations showing the loads imposed on the foundations and the resultant bearin pressure and uplift resistance of the foundations.

10.7 Shop Detail Drawings

Shop detail drawings showing all shop details including all dimensions slip joint or flanges, bevel cutting, bending and the identification mark and weight for each element. The Contractor shall not proceed with the shop detail drawings until the outline drawings and design stress diagrams have been approved by the Engineer.

10.8 Erection Drawings

Erection drawings showing each element or section with its identification mark, location and position of the outstanding pole element number and size of connection bolts and all erection details.

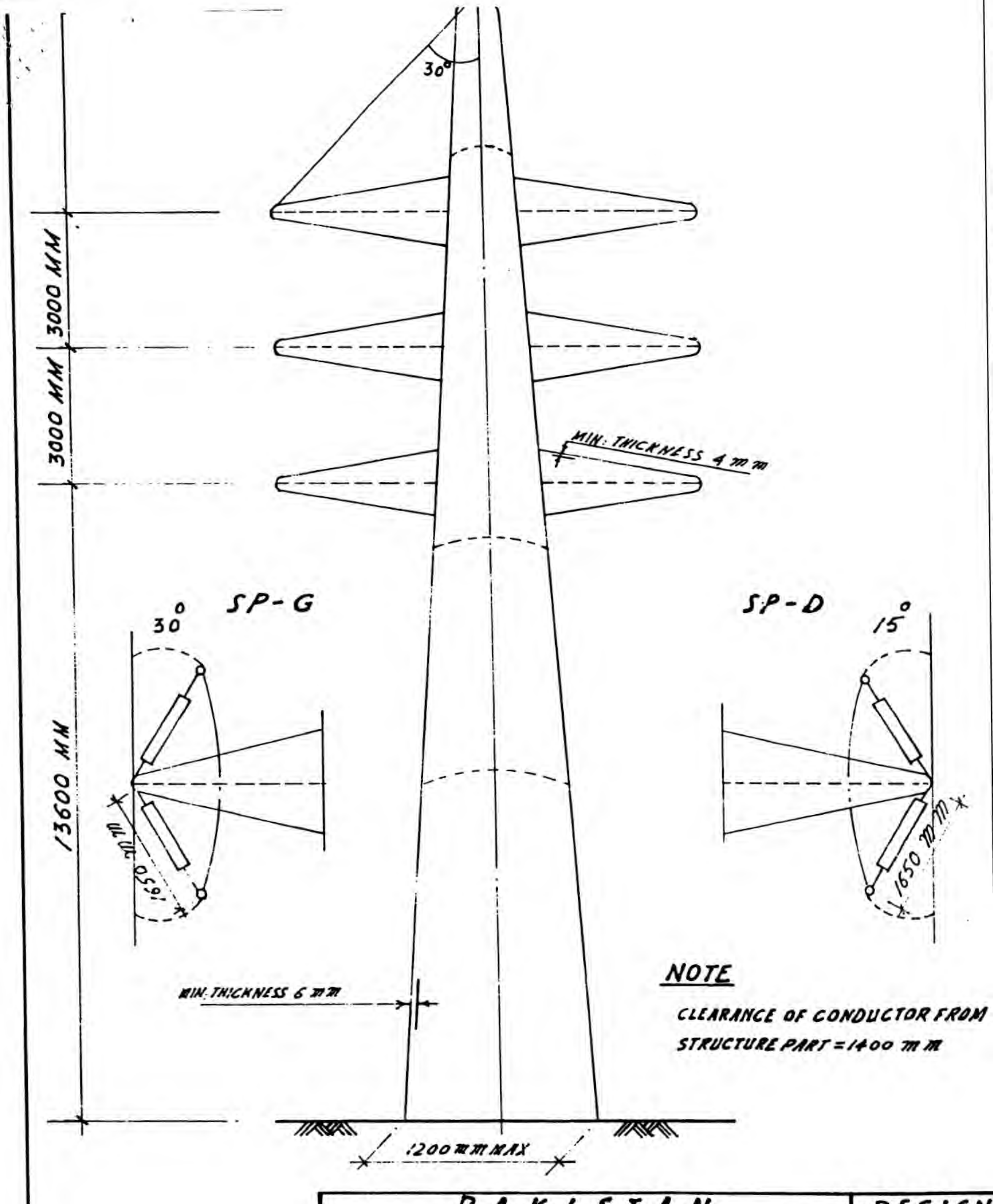
10.9 Footing Installation Drawings

Footing erection drawings showing embedded part with its identification mark or all dimensions required for the proper setting and positioning of anchor bolts with relation to the centre of the pole.

10.10 Bills of Material

Bills of material for each pole shall show the quantity, kind, outside diameter, inside diameter thickness, length weight and assembly mark for each section, including bolts, washers, plates and all fittings complete for each poles.

Encls: 1. Dwg. No. PDW/TC-220
2. Dwg. No. PDW/TC-221
3. Dwg. No. PDW/DF-207
4. Dwg. No. PDW/DF-314
5. Dwg. No. PDW/DF-319
6. Dwg. No. PDW/DF-327
7. Dwg. No. EW/TC-42
8. Dwg. No. GW/TZ-07

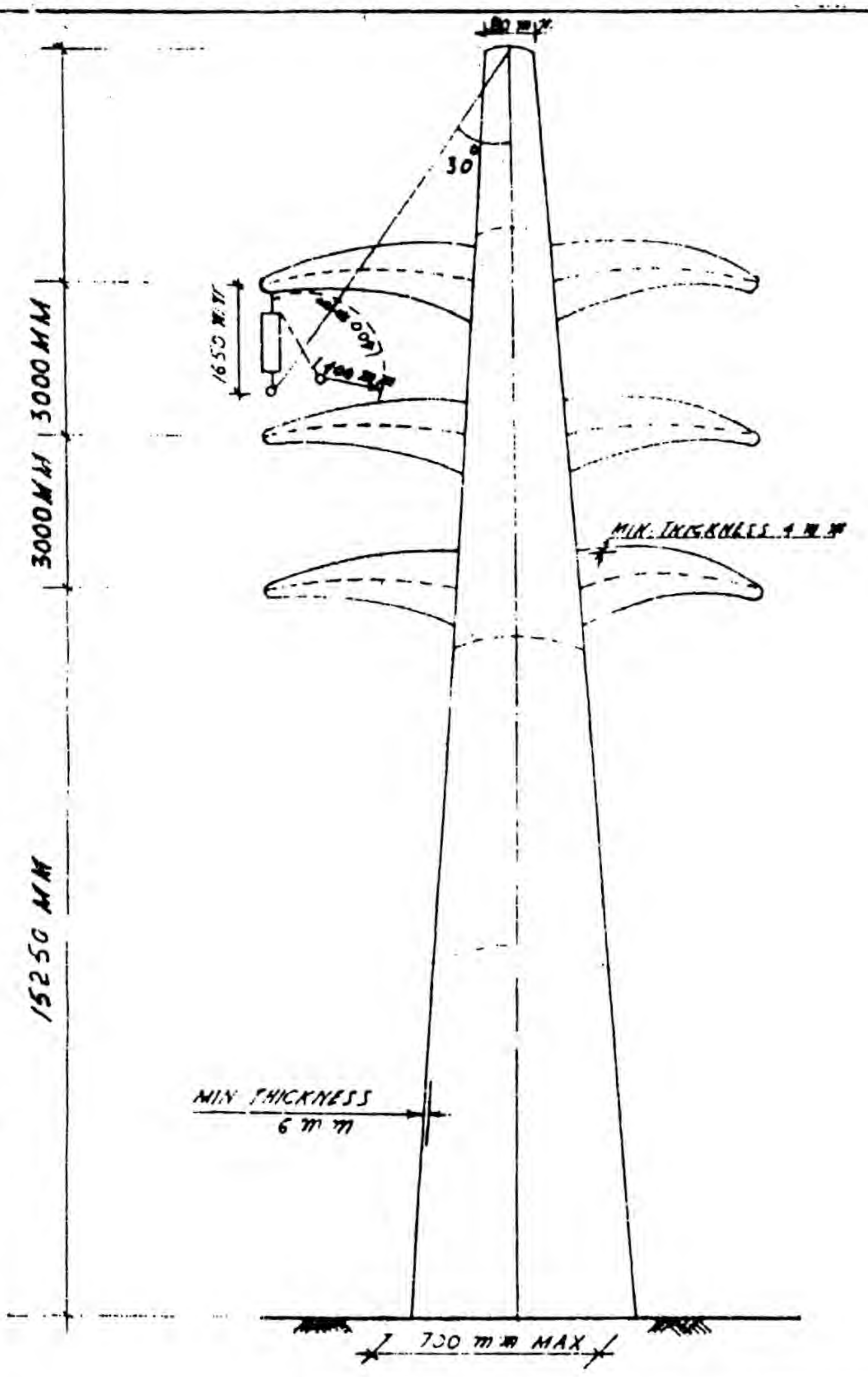


NOTE

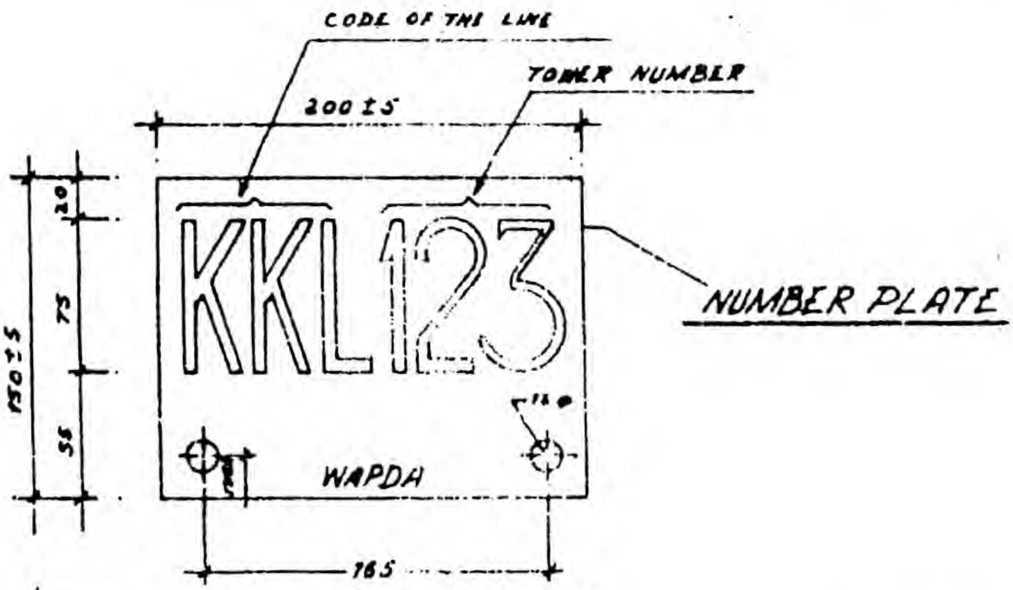
CLEARANCE OF CONDUCTOR FROM STRUCTURE PART = 1400 mm

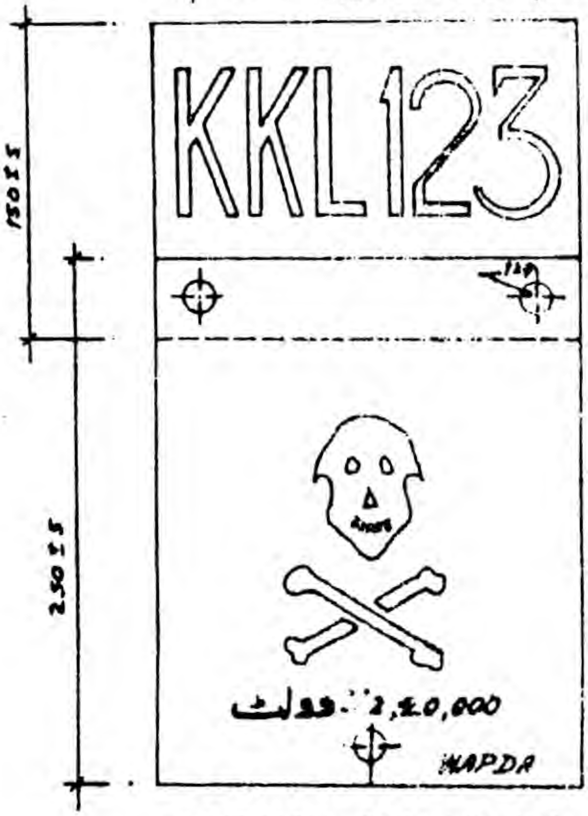
PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY			DESIGN DEPARTMENT POWER
DRAWN	AZHAR SHAH	[signature] 31/1/83	POLE TYPE SP-D & SP-G
CHECKED	MUBARIK ALI		
JUNIOR ENGINEER	NAEEM ASGHAR	[signature]	
SENIOR ENGINEER	MUNAWAR-A-MALIK	[signature]	
DIRECTOR	S. ISHTIAQ HUSSAIN SHAH	[signature]	SCALE ✓ DATE. 1.2.1983
CHIEF ENGINEER	M. A. SHAH	[signature]	DWG: NO. PDW/TC.22

PDW/TC-22

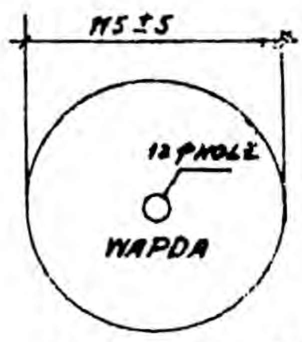


PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY			DESIGN DEPARTMENT POWER
DRAWN	AZHAR SHAH		POLE TYPE SP-A
CHECKED	[illegible] ALI		
JUNIOR ENGINEER	[illegible]		
SENIOR ENGINEER	[illegible]		
DIRECTOR	[illegible]		SCALE ✓ — DATE 1.3.1983
CHIEF ENGINEER	M. A. [illegible]		DWG: NO. PDW/TC.221





ASSEMBLY OF NUMBER & DANGER PLATE OF TRANSMI-
-SSION LINE



PHASE PLATE

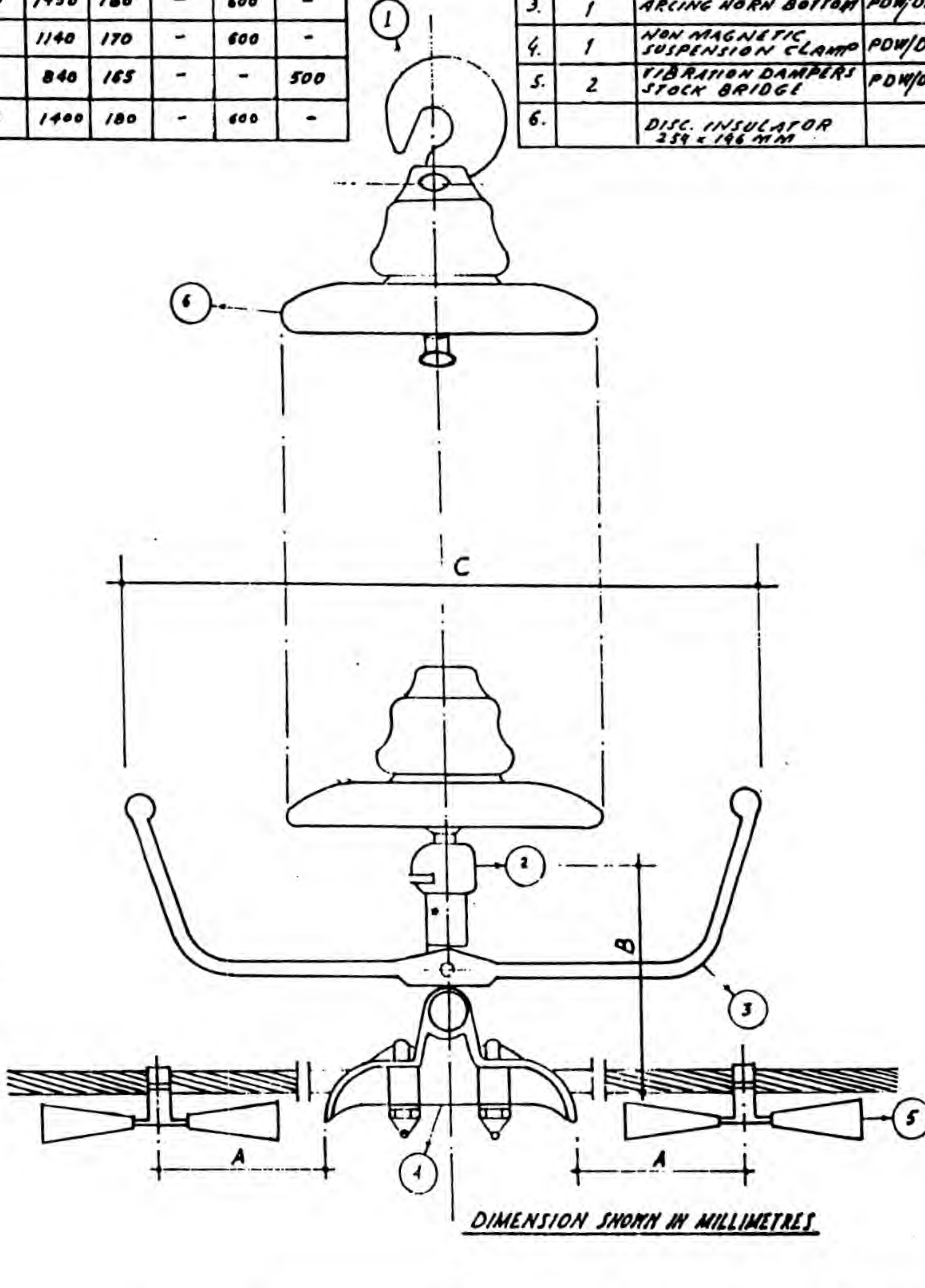
COLOUR, RED, YELLOW, & BLUE

ALL DIMENSIONS IN MILLIMETRES.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY			DESIGN DEPTT: POWER
NUMBER PLATE & PHASE PLATE FOR TRANSMISSION LINES.			
TRD.	A.E.	SCALE:-	DATE:- 13-4-76
DRN.	D.D.	DWG NO. PDW/DF-207	
CKD.	DIR.		

CONDUCTOR DESIGNATION	DIMENSIONS A	B	C 220 KV	132 KV	66 KV
RAIL	1525	180	750	600	-
CUCKOO	1450	180	-	600	-
LYNX	1140	170	-	600	-
DOG	840	165	-	-	500
CARDINAL	1400	180	-	600	-

ITEM	QTY.	DESCRIPTION	DWG. No.
1.	1	SELF LOCKING BALL HOOK	PDW/DF315
2.	1	SOCKET EYE	PDW/DF316
3.	1	ARCING HORN BOTTOM	PDW/DF317
4.	1	NON MAGNETIC SUSPENSION CLAMP	PDW/DF318
5.	2	VIBRATION DAMPERS STOCK BRIDGE	PDW/DF322
6.		DISC. INSULATOR 254 x 146 MM	



DIMENSION SHOWN IN MILLIMETRES

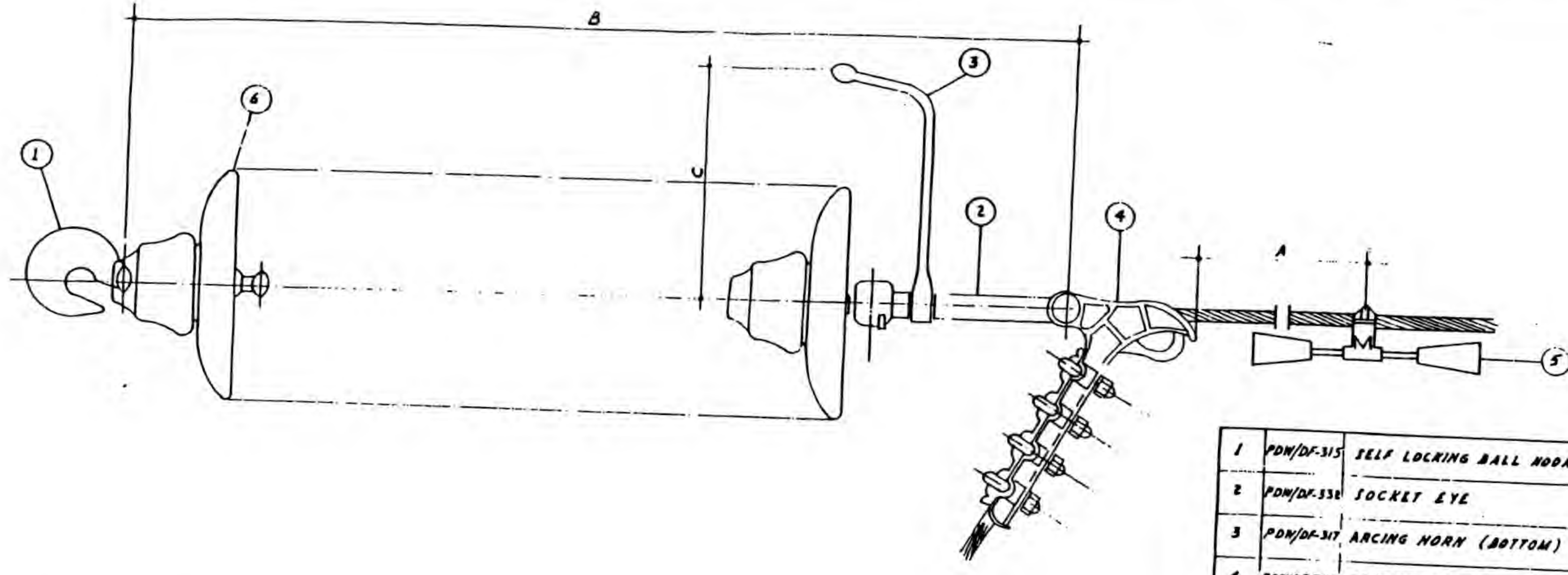
PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY	DESIGN DEPARTMENT
DRAWN	AZHAR SHAH
CHECKED	GHULAM RASUL
JUNIOR ENGINEER	NAZAR ABBAS
SENIOR ENGINEER	MUNAWAR-A-MALIK
DIRECTOR	S. ISHTIAQ HUSSAIN
CHIEF ENGINEER	JAVID AKHTER

SINGLE SUSPENSION STRING

SCALE ✓ DATE 27-9-80

DWG: NO. PDW/DF-314

NO	DATE	REVISIONS	BY
1	20-9.82	DIMENSION FOR ACSR CARDINAL CONDUCTOR ADDED	



1	PDW/DF-315	SELF LOCKING BALL HOOK
2	PDW/DF-338	SOCKET EYE
3	PDW/DF-317	ARCING HORN (BOTTOM)
4	PDW/DF-320	TENSION CLAMP
5	PDW/DF-322	VIBRATION DAMPERS (STOCK BRIDGE
6		DISC INSULATORS

CONDUCTOR DESIGNATION	DIMENSIONS				
	A	B	C		
			220KV	132KV	66KV
RAIL	1525	—	375	300	—
CUCKOO	1450	—	—	300	—
LYNX	1140	1735	—	300	—
DOG	840	986	—	—	250

☐ INDICATES BINDING DIMENSION

DIMENSION SHOWN IN MILLIMETRES

NO	DATE	REVISIONS	BY

PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY — DESIGN DEPARTMENT

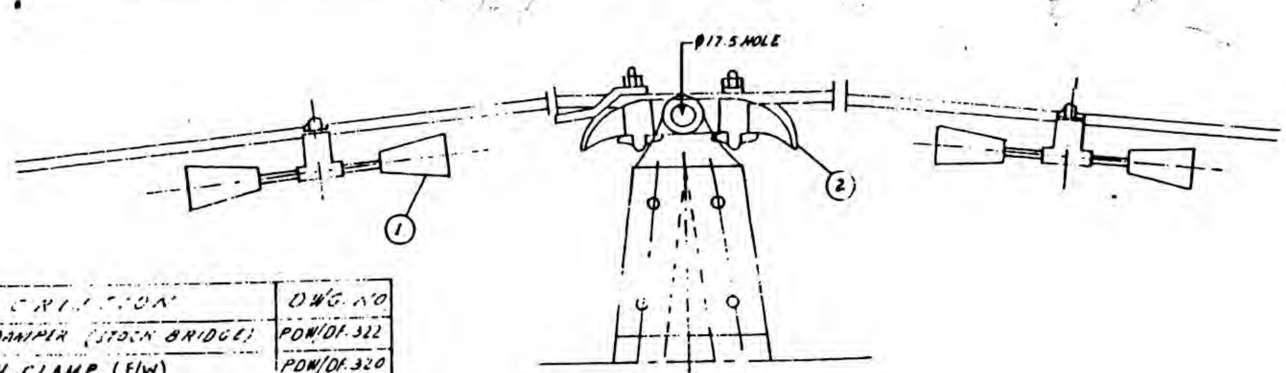
DRAWN	AZHAR SHAH	
CHECKED	GHULAM RASUL	
JUNIOR ENGINEER	NAZAR ABBAS	
SENIOR ENGINEER	MUHAMMAD-A-MALIK	
DIRECTOR	[illegible]	
CHIEF ENGINEER	JAVID AKHTER	

SINGLE TENSION STRING

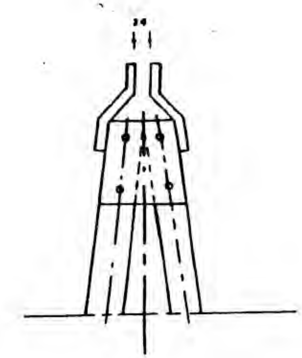
SCALE

DATE [illegible]-10-1980

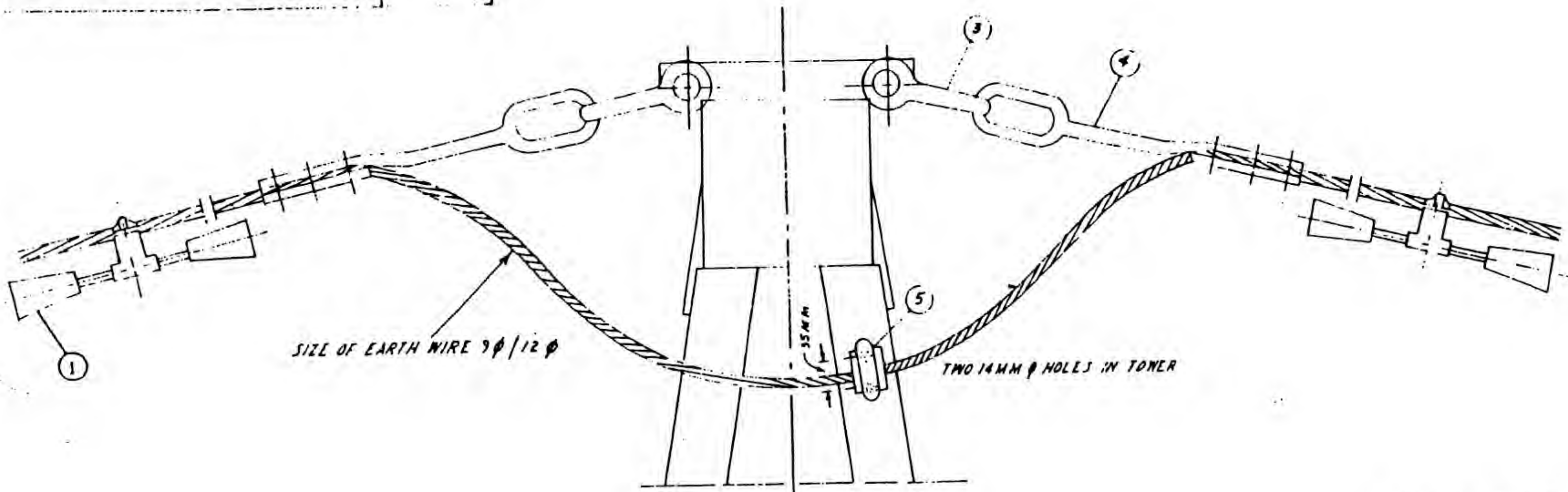
DWG: NO PDW/DF-32[illegible]



SUSPENSION ARRANGEMENT



ITEM	QTY.	DESCRIPTION	DWG. NO
1.	2	VIBRATION DAMPER (STOCK BRIDGE)	POW/DF.322
2.	1	SUSPENSION CLAMP (E/W)	POW/DF.320
3.	2	SHACKLE (E/W)	POW/DF.321
4.	2	TENSION CLAMP (E/W)	POW/DF.321
5.	1	EARTHING CLAMP	POW/DF.321

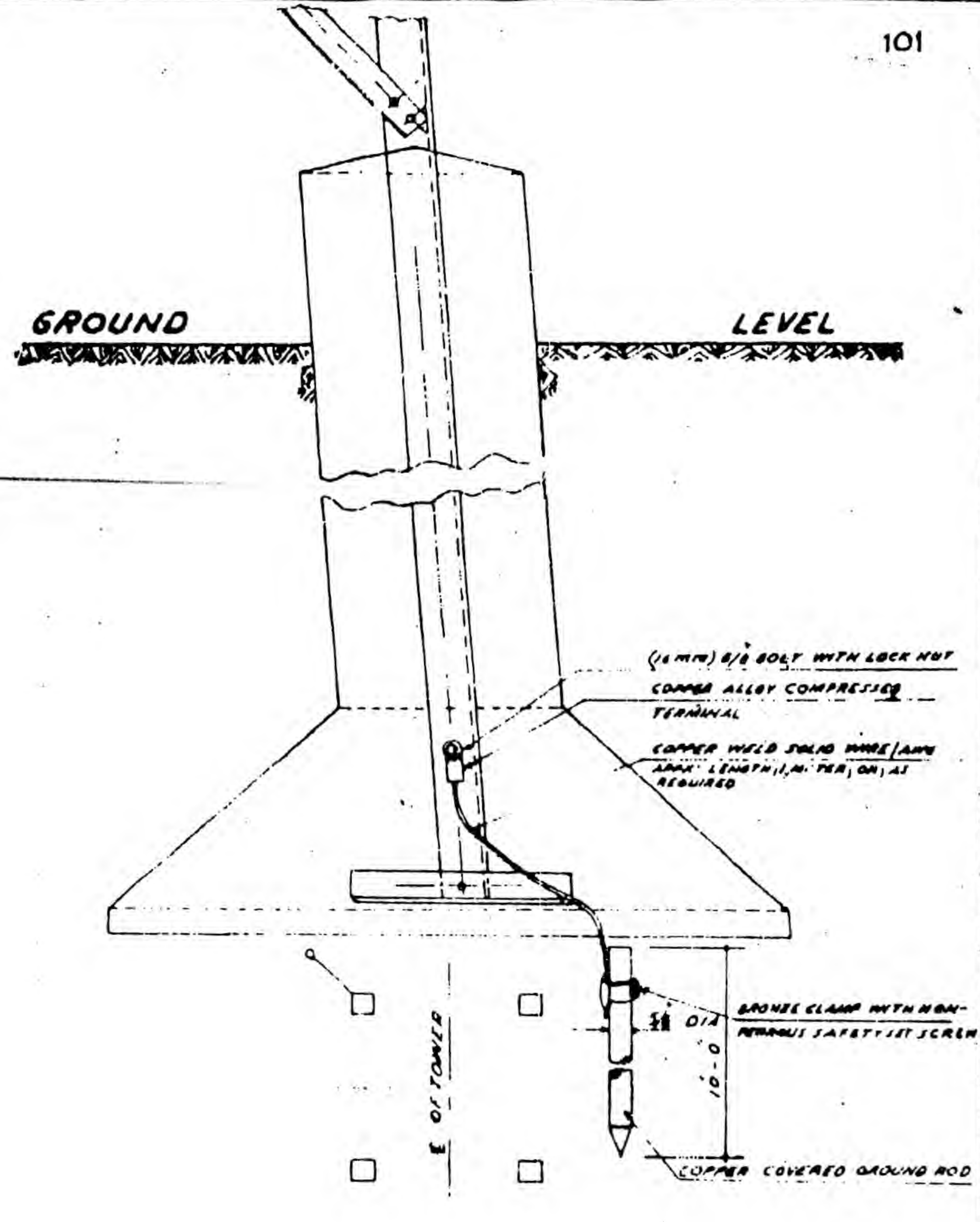


TENSION ARRANGEMENT

DIMENSION SHOWN IN MILLIMETRES

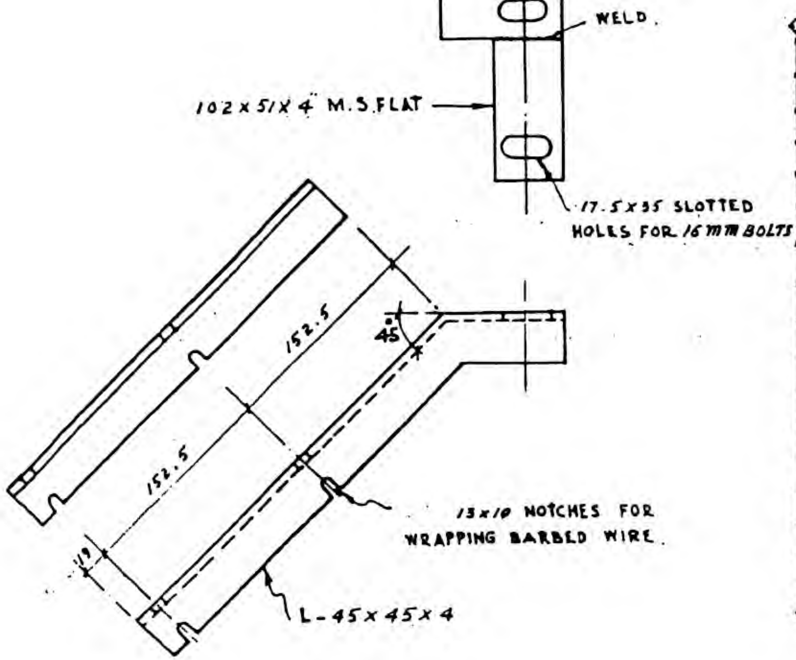
PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY				DESIGN DEPARTMENT
DRAWN	AZHAR SHAH	[signature]	EARTH WIRE SUSPENSION AND TENSION ASSEMBLIES	
CHECKED	GHULAM RASUL	[signature]		
JUNIOR ENGINEER	NAZAR ABBAS	[signature]		
SENIOR ENGINEER	MUNAWAR-A-MALIK	[signature]		
DIRECTOR	S. ISHTIAQ HUSSAIN		SCALE	DATE 27-9-80
CHIEF	JAVID AKHTER	[signature]	DWG. NO POW/DF-319	

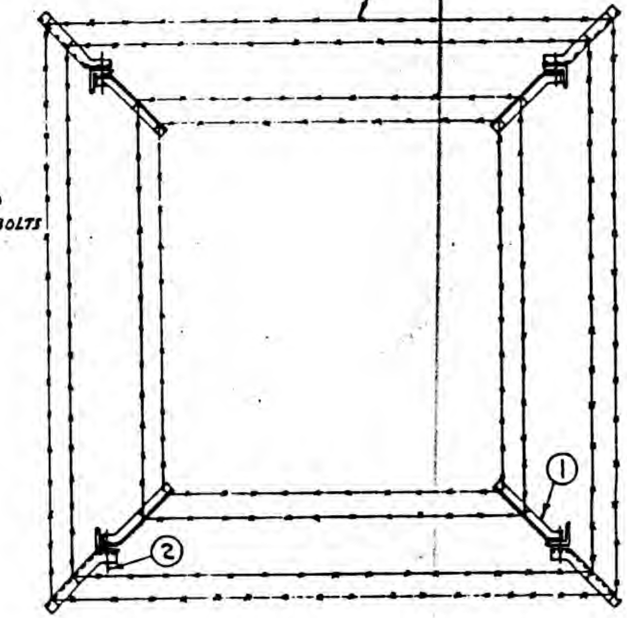
NO.	DATE	REVISIONS	BY



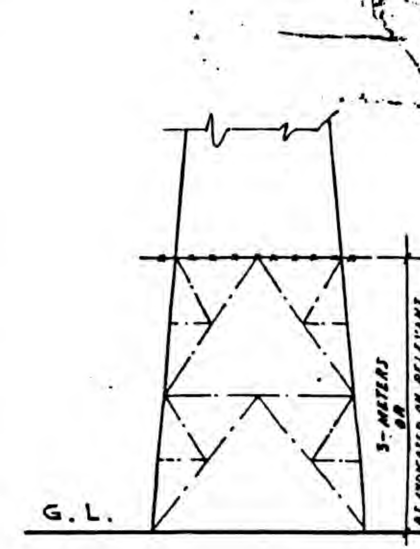
PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY				DESIGN DEPARTMENT (POWER)
DRAWN			EARTHING ARRANGEMENT	
CHECKED	A LATIF			
JUNIOR ENGINEER	M. A. SHAH			
SENIOR ENGINEER				
DIRECTOR	S. I. HUSSAIN		SCALE :-	DATE :
CHIEF ENGINEER			DWG: NO. EW/TC-42	

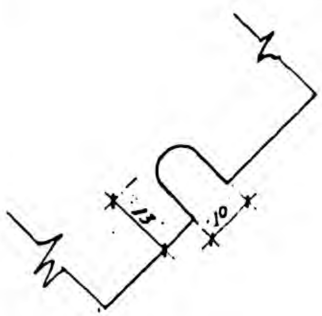
NO	DATE	REVISION	BY
1		DRAWING RETRACED	



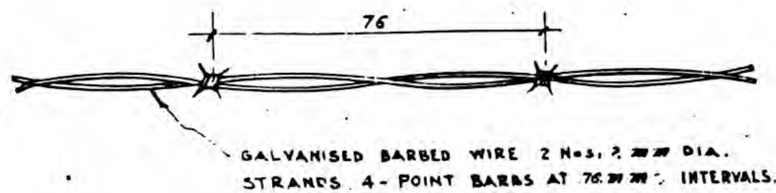


ASSEMBLY OF DEVICES
ON TOWER





ENLARGED DETAIL OF NOTCH



ADOPTED FROM "AMERICAN BRIDGE COMPANY" DWG. No. U/TT-901, FOR 'UHL' RIVER SCHEME TRANSMISSION LINE.

NO	ITEMS
1	ANGLE IRON 45 x 45 x 4
2	M.S. BOLT & NUT 16 mm φ 45 mm LONG
3	BARBED WIRE 2 mm DIA.

DATE	No.	REVISIONS

WEST PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY

STANDARDS AND DESIGN

ANTI-CLIMBING DEVICE FOR TRANSMISSION TOWERS.

DWN. G. [illegible]
TCD. [illegible]
CKD. G. [illegible]
A.E.
[illegible] 1/3/65 W.D
APVD.
DIRECTOR
SCALE: —
DATE: 15.3.65
NO. GW/TZ-[illegible]

SPECIFICATION P-8 :96

DISC TYPE PORCELAIN INSULATORS
(BALL AND SOCKET COUPLING TRANMISSION CLASS)

PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY
DESIGN DEPARTMENT (T&G) POWER

C O N T E N T S

PRINTING HISTORY

First approved on November, 1967.
First revision on August, 1982.
Second revision on March, 1984.
Third revision on November, 1985.
Fourth revision on October, 1989.
Fifth revision on January, 1996

SPECIFICATION P-8:96

DISC TYPE PORCELAIN INSULATORS

(Ball & Socket Coupling - Transmission Class)

0 FOREWORD

0.1 This specification has been prepared by Design Department (T&G) WAPDA and lays down the requirements for disc type procelain insulators with ball and socket coupling for use on transmission system.

0.2 This specification is comprehensive and should facilitate procurement of quality material. It does not include provisions of Contract.

0.3 This edition is the fifth revised version of original specification introduced in 1967.Major additions incorporated in this version are inclusion of steep wave front test, power arc test and autoclave expansion test for portland cememt.

0.4 This specification is mainly based on following interntional standards in respect of manufacturing and testing requirements. If, however, the requirements mentioned herein differ from those indicated in the relevant international standards, the requirements indicated herein shall prevail.

i) IEC Publication 120 (Dimensions of ball & socket couplings for string insulators)

ii) IEC Publication 372 (Locking devices for ball and socket coupling of string insulator units: Dimensions and Tests).

iii) IEC Publication 383 (Insulators for overhead lines with a nominal voltage above 1000 V).

iv) IEC Publication 575 (Thermal-mechanical performance tests and mechnical performance tests on string insulator units).

v) ANSI Publication C29.1- 1988 (Electrical power insulators - test methods).

vi) ASTM Publication C151-93a (Standard test method for autoclave expansion of portland cement).

0.5 This specification is subject to revision as and when required.

1 SCOPE

1.1 This specification covers disc type porcelain insulators with ball and socket coupling for use on over-head transmission system.

2 DEFINITIONS

2.1 Flashover

Flashover is a discharge through air, taking the form of an arc or a spark or of several arcs or sparks, connecting the parts of an insulator which normally have the operating voltage between them.

2.2 Leakage Distance

The leakage distance of an insualtor is the sum of the shortest distances measured along the insulating surfaces between the conductive parts, as arranged for dry flash over test.

2.3 Lot

A quantity of insulators manufactured or produced under conditions which are presumed uniform and offered for acceptance.

2.4 Mechanical Impact Strength

The mechanical impact strength of an insulator is the impact which, under specified conditions, the insulator can withstand without damage.

2.5 Puncture

Puncture is a local or total destruction of the insulating material caused by a discharge passing through it.

Note:- A fragment breaking away from the rim of a shed or damage to the insulator due to the heat of a surface discharge shall not be considered a puncture.

2.6 Radio-influence Voltage

The radio-influence voltage of an insulator is the radio frequency voltage produced, under specified conditions, by the application of an alternating voltage of 50 cycles per second +/- 5 percent.

2.7 Sample

Items selected from the lot to be subjected to the acceptance tests.

2.8 Simple Random Sample

A sample of n items taken from a population of N items in such a way that all possible combinations of n items have the same probability of being chosen.

2.9 Standard Atmospheric Conditions

For the purpose of this specification are :-

Abmient Temperature	25 deg.C
Barometric Pressure	1014 millibars, 760 mm (29.9 inches) of mercury.
Humidity	15 grams water per cubic metre, this is equivalent to a partial pressure of 15.46 mm (0.6 inch) of mercury at 25 deg.C.

2.10 Test Specimen

A test specimen is an insulator which is representative of the product being tested; it is a specimen that is undamaged in any way which would influence the result of the test.

2.11 Dry or Wet one-minute Power Frequency Test Voltage

This is a power frequency voltage which the disc insulator can withstand for one-minute dry or wet, under the conditions prescribed, without flashover or puncture.

2.13 24-Hour Mechanical Test Load of Disc Insulator

This is a mechanical load which the disc type insulator can withstand for 24 hours, under the conditions prescribed without breakage or puncture.

2.13 Short Time Electro-Mechanical Breaking Load of Disc Insulator

This is the mechanical load which, under the conditions prescribed, causes puncture or breakage of any part of the disc type insulator unit.

2.14 Mechanical Breaking Load of Disc Insulator

This is the mechanical load which, under the conditions prescribed, causes separation of the metal parts.

2.15 Puncture Voltage

The puncture voltage of an insulator is the voltage, which, under the conditions prescribed, causes puncture.

3 GENERAL

3.1 Standard insulators shall conform in all respects to the requirements stated hereinafter.

3.2 Manufacturer's drawings shall be supplied and shall show the outline of the insulator together with all pertinent dimensions. Any possible variation in these dimensions due to manufacturing tolerance shall be indicated.

4 MATERIAL

4.1 The insulators shall be made of good commerical grade wet process porcelain.

4.2 The entire surface of the insulators shall be smoothly glazed. The standard colour of the glaze shall be as indicated in Table-I. The entire surface shall be free from imperfections.

4.3 Metal parts, except for split pins, shall be made of a good malleable iron, ductile cast iron or open hearth or electric furnace steel, and galvanized according to Clause-6.

4.4 The insulator unit shall be designed to inhibit the accelerated corrosion of metal fittings due to leakage currents. A corrosion intercepting zinc sleeve shall be used on the insulator coupling pin for Fog type insulators.

4.5 The design of the isulator shall be "straight headed" with sanding of the porcelain internally and externally where the metal work is cemented to the porcelain.

5 DIMENSIONS AND CHARACTERISTICS

5.1 Dimensions and Characteristics shall conform to values given in Fig-I and Table-I.

5.2 Coupling

Dimensions of standard ball and socket coupling shall conform to the IEC Publication 120.

5.3 Locking Devices

Standard split pin locking device shall have the shapes and dimensions in accordance with IEC Publication 372-1 and Fig:2 of this Specification.

5.3.1 Material

The material for split pin shall be standard quality stainless steel or bronze, having quality of resistance to internal corrosion.

6 GALVANIZATION

6.1 Ferrous parts shall be hot dip galvanized with zinc coating conforming the tests carried out as per WAPDA Specification P-82.

6.2 Please add the following for "Class B Castings" at Page 3 after 2nd line in Wapda Specification P-82:-

"Class B Castings to be used for Fog type insulators.	Castings, Cast iron, malleable iron & steel to be used for Fog type insulators.	1050	1080"

7 TESTS

7.1 Type Tests

7.1.1 These tests are intended to verify the main electrical characteristics of an insulator which depend primarily on its shape and size. They are made once only on insualtors.

7.1.2 Following type tests are to be carried out in accordance with the requirements and methods laid down in the publications mentioned therewith.

i. Dry lightnig impulse withstand voltage test (IEC 383)

ii. Dry power frequency withstand voltage test (IEC 383).

iii. Wet power frequency withstand voltage test (IEC 383)

iv. Thermal-mechanical performance test (As per sub clause 8.1.5 of this specification)

v. Radio influence voltage test (ANSI C29. 1-1988).

7.2 Sample Tests

7.2.1 These tests are for the purpose of verifying the other characteristics of an insulator and the quality of the materials used. They are made on insulators taken at random from batches offered for acceptance.

7.2.2 Insulator

Following sample tests shall be carried out in accordance with standard mentioned therewith:-

(i) Verification of dimensions (IEC 383 and Table-I)

(ii) Temperature cycle test (IEC 383)

(iii) Electro-mechanical failing load test (IEC 383)

(iv) Porosity test (IEC 383)

(v) Galvanizing test (WAPDA Spec. P-82:80)

(vi) Power frequency puncture withstand test (IEC 383)

(vii) Thermal-Mechanical Performance Test (As indicated in sub-clause 8.1.5 of this specification).

(viii) Autoclave Expansion Test for Portland Cement (As indicated in sub-clause 8.1.6 of this specificaiton).

(ix) Steep Wave Front Impulse Test (as indicated in sub clause 8.1.7 of this specification).

(x) Power Arc Test (as indicated in sub-clause 8.1.8 of this specification).

7.2.3 Locking Device for Ball & Socket Coupling

Following sample tests are to be carried out in accordance with methods given in IEC 372 and the Fig:2 of this specification:-

i. Visual Examination

ii. Verification of Dimensions

iii. Verification of Resistance to Bending

iv. Hardness Test

v. Operation Test

7.3 Routine Tests

These tests are for the purpose of eliminating insulators with manufacturing defects. They are made on every insulator offered for acceptance by the manufacturer. Following routine tests are required in accordance with IEC 383:-

i. Visual Examination

ii. Mechanical Routine Tests

iii. Electrical Routine Tests

8 SAMPLING RULES, TEST METHODS AND ACCEPTANCE CRITERIA FOR SAMPLE TESTS

8.1 Rules for Insulator Sampling and their Distribution for Tests

8.1.1 For sample tests, insulators shall be offered in lots of 5000 units. The insulators intended for the sample tests shall be taken at random from each lot by the inspector after performing routine tests of IEC Publication 383 and elimination of any defective insulator.

8.1.2 The number "n" of insulators to be selected is indicated in Table-II below:-

TABLE-II SAMPLING

Number of insulators selected from the lot	Number of insulators in the Ist partial sample	Number of insulators in the 2nd partial sample
n	n1	n2
14	10	4

The total sample of 'n' insulators is further divided into two partial samples composed of "n1" and "n2" insulators.

8.1.3 The sample of "n1" insulators is subjected to the following tests of IEC Publication 383 which are applicable in the order indicated. The acceptance criteria shall be in accordance with IEC-383 except for electro-mechanical test, for which, the acceptance criteria mentioned in sub-clause 8.1.3.1 shall apply.

(i) Verification of dimensions

(ii) Temperature cycle test

(iii) Electro-mechanical test. The load shall be increased until the failing load of the insulator. The value obtained will be used for the statistical analysis. The acceptance criteria shall be as under:-

8.1.3.1 While performing electro-mechanical test, the process for the decision of acceptance shall be as follows:-

1) Compute the quality index Qs with the following formula:

$$Qs = \frac{\bar{R} - Rs}{S}$$

In this formula:

- Average value $\bar{R} = \dfrac{R1 + R2 + \ldots\ldots + Rn1}{n1}$

R1, R2, R3,.......,Rn1 are the measured values of electro-mechanical failing load.

- Rs : specified value of the electro-mechanical failing load.

- Standard deviation:

$$S = \sqrt{\frac{\sum_1^{n1}(R - \bar{R})^2}{n1 - 1}}$$

If Qs $\geq$ 3, the lot meets the acceptability criterion.

If Qs $<$ 3, the lot does not meet the acceptability criterion.

8.1.4 The sample of "n2" insulators is subjected to the following tests of IEC Publication 383 which are applicable with the acceptance criteria specified in that Publication:

(i) Verification of dimensions

(ii) Temperature cycle test

(iii) Power Frequency Puncture test

(iv) Galvanizing test

(v) Porosity test

8.1.5 For thermal-mechnical performance test, ten (10) insulator units of each type shall be selected at random from the first lot and tested in accordance with IEC publication 575; latest revision except that the temperature variations shall be from - 5 deg.C. to 65 deg.C. and the criteria for acceptance of the lot shall be as below:-

a) The results of the performance tests shall match the results of ordinary electro-mechanical failing load test. Thus the specified electro-mechanical failing load that applies to the ordinary electro-mechanical failing load test should be reached also in the performance tests.

b) Fracture pattern shall not change.

c) Electrical puncture or shattering should not occur before reaching the maximum load and the ultimate fracture.

d) The acceptance criteria shall be same as for electromechanical test indicated in sub-clause 8.1.3.1.

8.1.6 The soundness of portland Cement to be used as the bonding agent for insulators shall be tested in accordance with ASTM C151 "Standard Test Method for Autoclave Expansion of Portland Cement." Six (6) samples of cement for the test specimens shall be selected at random from the batch to be used for insulators.

The bars prepared from neat cement when subjected to high pressure steam at 295 psi for three hours at 216 deg.C shall not show an expansion of more than 0.12 percent. The expansion of cement more than 0.12 percent in the test shall cause rejection of the whole batch of cement brought for acceptance.

Alternatively the soundness of Portland Cement may be tested on the full assembled insulators as described below:-

Ten (10) insulator units of each type shall be selected at random from the first lot and tested in accordance with ASTM C151-93a. After this test, each unit shall be subjected to Electro-mechanical failing load test (IEC 383). The acceptance criteria shall be the same as for electro-mechanical test indicated in sub-clause 8.1.3.1

8.1.7 For steep wavefront impluse test, five (5) insulator units shall be selected at random from the first lot brought for acceptance:-

a) Insulators shall be subjected to ten successive positive and negative impulses of flash over voltage with wave having an effective rate of rise of 835 KV per micro second.

b) Each unit shall then be subjected to three flash overs of low frequency dry flash over test of ANSI C29.1 latest revision and shall pass a flash over test of not less than 95 PCT of the rated value.

c) In case of failure of any one unit of either of steep wavefront or flash over tests, another ten units shall be picked and re-tested. Failure of any one unit from this group of ten, to the test in (a) and (b) above, shall cause rejection of the lot brought for acceptance.

d) In case of non acceptance of one lot, subsequent lots shall be tested till a successful test indicates the design of the insulators has been corrected.

8.1.8 For power arc test, ten insulators shall be selected at random from the first lot. Each unit shall be attached to the lower end of a vertical string of five other insulators. Each string of six insulators thus formed shall be subjected to two flashovers of 12,000 rms symmetrical amperes for 5 cycles. The insulator string, when under test, shall be in the vertical position without conductor and arcing horn. The 50 cycle voltage shall be applied to the bottom of the string with ground at the top of the string. The insulators shall be stressed to 40% of the rated strength of the insulator. The flashover shall be initiated by a fuse wire connected from the cap of the top insulator to the pin of the bottom insulator. The mechanical strength of insulator units shall not be reduced below 65 percent of their rated strength after breaking with the power arcs as described above.

9 MARKING

Each insulator unit shall bear symbols identifying the manufacturer, year of manufacture and the rated combined Electrical and Mechanical strength. The marking shall be legible and durable.

10 PACKING

The packing shall be as per general conditions of the contract/order.

11 DRAWINGS AND DATA

11.1 Tender Drawings

The following information/documents shall be supplied with the bid. Failure to supply the same may cause disqualification of the bid:-

i. Detailed fully dimensioned drawings of insulators.

ii. Specification giving material grade composition of all parts of the insulators, and locking arrangements.

iii. Catalogues/literature.

iv. Detail of manufacturing and testing facilities available with manufacturer.

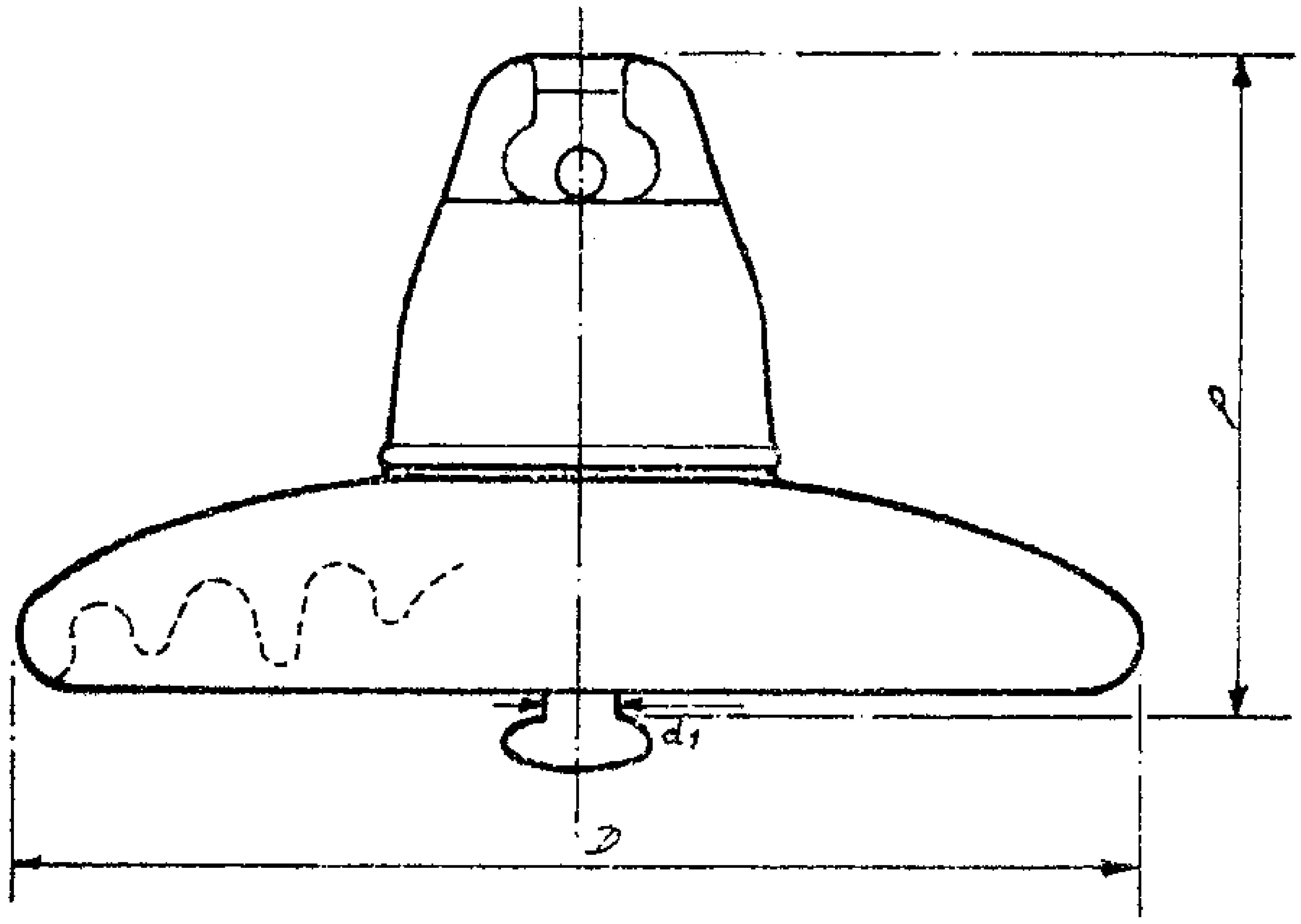
v. The information indicated in table-I of the specification.

vi. Certified type test reports, preferably from an independant laboratory.

11.2 Approval Drawings

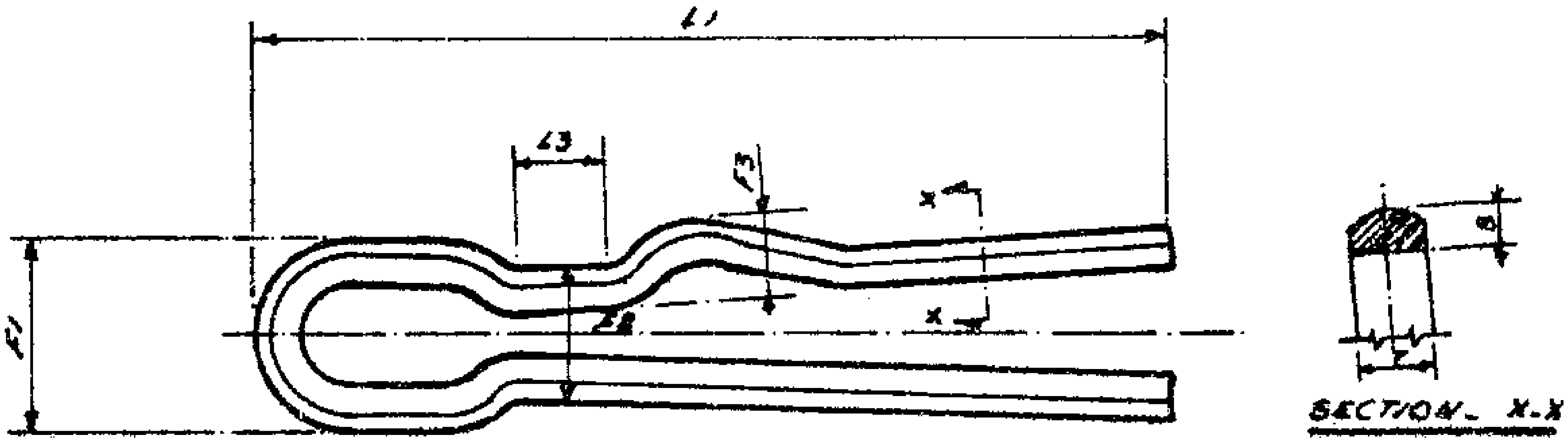
All information indicated in sub clause 11.1 above shall be submitted for approval of the Engineer prior to commencment of mass production.

Encls: Fig. 1 and 2



TRANSMISSIAN CLASS STRAIGHT HEAD DISC INSULATOR

FIG_ I



DIMENSIAN STANDARD SIZE	L 1		L3	F 1		F2		F3		T		S	
	MINI:	MAXI:	MINI:	MINI:	MAXI:	MINI:	MAXI:	MINI:	MAXI:	MINI:	MAXI:	MINI:	MAXI:
15 A	63·5	66·5	4·7	14	15	10·3	10·7	5·3	5·7	5·5	5·7	3·1	3·3
20	78·5	81·5	6	15·9	16·9	10·7	11·1	5·8	6·2	7	7·2	3·1	3.3

FIG. 2

TYPE DESIGNATION	U70BL	U80BL	U100BL	U160BS	U70BLF	U80BBLF	U100BLF	U160BSF
DIMENSIONS								
Disc Diameter (D),mm	255	255	255	280	255	255	255	212
Disc spacing(P),mm	146	146	146	146	146	146	146	146
Minimum Creepage Distance, mm	290	290	290	300	430	430	430	470
Standard Coupling dia (d1), mm	16	16	16	16	16	16	16	20
MECHANICAL VALUES								
Short-time electro mechanical breaking load, KN	70	80	100	160	70	80	100	100
Mechanical Routine test load, KN	28	32	40	64	28	32	40	64
Mechanical Impact strength, Nm	6.2	6.2	11.3	11.3	6.2	6.2	11.3	11.3
ELECTRICAL VALUES								
Power Frequency with-stand voltage,KV	70	70	70	70	85	85	85	85
Wet power frequency withstand voltage,KV	40	40	40	40	50	50	50	50
Impulse withstand voltage, KV	110	110	110	110	110	110	110	110
Low frequency puncture voltage, KV	110	110	110	110	130	130	130	130
RADIO NOISE								
Max.radio influence voltage at 1000KHz, micro volts	50	50	50	50	50	50	50	50
Test voltage to ground, KV	10	10	10	10	10	10	10	10
Colour of glaze	Brown	White	Grey	Brown	Brown	White	Grey	Brown

SPECIFICATION P-140:82

SUSPENSION STRINGS

PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY
(DESIGN DEPARTMENT POWER)

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CONTENTS

PRINTING HISTORY

First approved on. 21.7.80

First revision on December, 1982.

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SPECIFICATION P-140: 82

SUSPENSICN STRINGS

0 FOREWORD

0.1 This standard has been introduced by WAPDA and has been prepared by the Transmission Line Section of the office of the Chief Engineer (Design).

0.2 This standard is intended only for the purpose of technical specification to facilitate procurement of materials and does not include provision of contract.

0.3 This specification is subject to periodic revision as and when required.

1 SCOPE

1.1 This specification covers the hardware of suspension strings for transmission lines.

2 TYPES OF SUSPENSION STRINGS

2.1 Suspension string described in this specification are of the following types:

Description	String Designation	Cond:O.D. (mm)
a) Single Suspension string for "DOG"	SS-D	14.2
b) Single Suspension string for "LYNX"	SS-L	19.5
c) Single Suspension string for "CUCKOO"	SS-C	27.7
d) Single Suspension string for "RAIL"	SS-R	29.6
e) Single Suspension string for "CARDINAL"	SS-CA	30.4
f) Double Suspension string for "DOG"	DS-D	14.2
g) Double Suspension string for "LYNX"	DS-L	19.5
h) Double Suspension string for "CUCKOO"	DS-C	27.7
i) Double Suspension string for "RAIL"	DS-R	29.6
j) Double Suspension string for "CARDINAL"	DS-CA	30.4

The hardware used in the suspension string described above in this specification has been designated by the code numbers. These codes have been assigned in the following manner:

i) The first letter 'S' stands for single and 'D' for Double.

ii) The next letter 'S' stands for Suspension.

iii) The succeeding letters stand for the name of conductor for which the hardware is meant for i.e. 'D' for Dog 'L' for Lynx, 'C' for Cuckoo, 'R' for Rail and 'CA' for Cardinal.

3 RATINGS OF HARDWARE

3.1 The hardware shall be of the ratings as specified in Table-I and Table-II below:

TABLE - I

RATINGS OF HARDWARE FOR SINGLE SUSPENSION STRING

Sr. No.	Description	Failing Load Kg.				
		SS-D	SS-L	SS-C	SS-R	SS-CA
1.	Ball hook	8000	8000	12000	12000	16000
2.	Socket eye	8000	8000	12000	12000	16000
3.	Arcing Horn	150	150	150	150	150
4.	Suspension Clamp:					
	i) Resistance to Conductor slippage	600	1500	2500	2500	3350
	ii) Vertically applied load	8000	8000	12000	12000	16000

TABLE - II

RATINGS OF HARDWARE FOR DOUBLE SUSPENSION STRING

Sr. No.	Description	Failing Load Kg.				
		DS-D	DS-L	DS-C	DS-R	DS-CA
1.	Ball Hook	12000	12000	20,000	20,000	25,000
2.	Socket Clevis Type A	12000	12000	20,000	20,000	25,000
3.	Yoke Plates	12000	12000	20,000	20,000	25,000
4.	Ball Clevis	8000	8000	12,000	12,000	16,000
5.	Socket Clevis Type B	8000	8000	12,000	12,000	16,000

Sr. No.	Description	Failing Load Kg. DS-D	DS-L	DS-C	DS-R	DS-CA
6.	Arcing Horn Bottom	150	150	150	150	150
7.	Eye Clevis	12000	12000	20,000	20,000	25,000
8.	Suspension Clamp:					
	i) Resistance to Conductor slippage	600	1500	2,500	2,500	3,350
	ii) Vertically applied load	8000	8000	12,000	12,000	16,000

4 GENERAL REQUIREMENTS

4.1 Each single suspension string hardware shall consist of:

1 Self locking ball hook
1 Socket eye
1 Arcing horn bottom
1 Non magnetic suspension clamp

4.2 Each double suspension string hardware shall consist of:

1 Self locking ball hook
1 Socket clevis type 'A'
2 Yoke plates
2 Ball clevis
2 Socket clevis type 'B'
1 Arcing horn
1 Eye clevis
1 Suspension clamp

4.3 The ball and socket shall be of size IEC, 16mmA, and shall conform to WAPDA Specification P-8:82 (latest revision).

4.4 All ferrous parts shall be hot dip galvanized in accordance with WAPDA Specification P-82:81 (latest revision).

4.5 The parts of hardware that mate with each other shall not have a play clearance of more than 2mm.

5 DIMENSIONS AND TOLERANCES

All hardware shall generally be in accordance with drawings forming a part of this Specification.

The dimensions of these parts of hardware that mate with other hardware or that determine the length of insulator string are binding and are shown enclosed on the drawing.

For dimensions that are fixed and binding the tolerance will be plus or minus 2 percent with a maximum of 0.8mm. For dimensions that are shown as Max. or Min. there shall be no plus and minus tolerance respectively. The tolerance in the opposite sense may however be 4%.

6 DESIGN AND MATERIAL

6.1 Self Locking Ball Hook

It shall be made from drop forged steel of suitable grade and shall be hot dip galvanized. The detail dimensions shall be according to Drawing No. PDW/DF-315.

6.2 Socket Eye

It shall be made from drop forged steel or malleable iron of suitable grade. It shall be hot dip galvanised. The detail dimension shall be according to Dwg. No. PDW/DF-316. It shall be supplied with a split pin made from half round brass wire protected against corrosion by appropriate coating and shall be able to work under hot line conditions.

6.3 Socket Clevis

These shall be made from drop forged steel or malleable iron of suitable grade. These shall be hot dip galvanized and shall be made according to Dwg. No. PDW/DF-376 and PDW/DF-378. The socket shall be supplied with a split pin made from half round brass wire protected against corrosion by an appropriate coating and shall be able to work under hot line conditions. The clevis shall be supplied with rivet round headed with aluminium alloy round washer and straight split pin. The split pin shall be made from cadmium plated brass or copper.

6.4 Yoke Plates

Yoke plates shall be of mono block or flat type and shall be made from high grade steel, hot dip galvanized and subject to normalizing process and shall be made according to Drawing No. PDW/DF-377.

6.5 Ball Clevis

It shall be made from drop forged steel of suitable grade and shall be hot dip galvanized. It shall be made according to Dwg. No. PDW/DF-382.

6.6 Arcing Horn

It shall be made from drop forged mild steel and shall be hot dip galvanized. The dimensions shall be according to

Drawing No. PDW.DF-317. The tolerance on the length shall be 5% with a maximum of 15mm:

6.7 Eye Clevis

It shall be made from drop forged steel of suitable grade and shall be hot dip galvanized. The detail dimensions shall be according to Dwg. No. PDW/DF-379. The clevis shall be supplied with rivet round headed with aluminium alloy round washer and straight split pin. The split pin shall be made from cadmium plated brass or copper.

The eye shall be supplied with a split pin made from half round brass wire protected against corrosion by an appropriate coating and shall be able to work under hot line conditions.

6.8 Conductor Suspension Clamps

Suspensions clamps shall be so designed that the effect of vibration, both on the conductor and on the fitting itself, are minimised. They shall be designed, manufactured and finished so as to avoid sharp radius of curvature, ridges and out growths which might lead to localized pressure or damage to the conductor in service. The clamp shall permit the conductor to slip before failure of the conductor occurs. The clamps shall have sufficient contact surface to minimize damage due to fault current.

The wire groove diameter shall be within the limits of 1.0 and 1.15 times the diameter of the conductor. Suspension clamp shall be made according to Dwg. No. PDW/DF-318. The bodies and keepers shall be of cast or forged high strength corrosion resistant aluminium alloy. Connecting pieces, bolts, nuts and locks washers shall be made of hot dip galvanized steel. Cotter pins shall be made of stainless steel. Edges and corners shall be rounded to minimise field contractions and radio interference.

7 TESTS

7.1 Type Tests

Type tests are intended to verify and established design characteristics. They shall be made once only on hardware identical in all essential details with those to be supplied.

The following type tests shall be carried out in according with clause 8,9 and 10.

i)	Mechanical Test	) On each individual item) or hardware
ii)	Resistance to conductor slippage test	) On suspension clamp only

iii) Corona Test) For complete insulator String.

7.2 Sample Tests

Sample tests shall be made to verify the quality and workmanship. The following sample test shall be performed in accordance with clause 8, 9, 11, 12, & 13.

i)	Visual examination	)
ii)	Verification of dimensions	) On each item of hardware
iii)	Mechanical test	)
iv)	Resistance to conductor slippage test	) On suspension clamp only
v)	Galvanising test	) On all ferrous parts

8 MECHANICAL TEST

8.1 For Hardware Except Arcing Horn

The fitting shall be held in tensile testing machine in a manner approximating as nearly as possible to the arrangement to be used in service. A tensile load equal to one-half of the specified minimum failing load shall be applied and increased at a steady rate. Failure of the fitting shall not occur at a load less than the specified minimum failing load as per Table-I & Table-II.

8.2 For Arcing Horn

Arcing horn shall be rigidly supported in a manner approximating as nearly as possible to the arrangement in service and a load of 150 Kg shall be applied parallel to the insulator string axis at each outer extremity of the fitting. The fitting shall not fail or show any signs of distortion or over-stressing of the material.

9 RESISTANCE TO CONDUCTOR SLIPPAGE TEST

Test piece shall be assembled in accordance with manufacturer's recommendations on conductors of the size and type with which it is to be used. The assembly shall be mounted in a tensile testing machine and anchored in a manner approximating as nearly as possible to the arrangement to be used in service, precautions being taken to avoid birdcaging of the conductor. The length of conductor joint in the test assembly should preferably be not less than 100 times the overall diameter of the conductor.

A tensile load of about 50% of the minimum failing load as specified in table-I and table-II shall be applied and the conductor shall be marked in such a way that movement relative to the fitting can easily be detected, without any subsequent adjustment of the fitting, the load shall be steadily increased to 95% of the minimum failing load and then reduced to 90% of the minimum failing load and maintained for 1 minute. There shall be no movement of the conductor relative to the fitting due to slip during this 1 minute period and no failure of the fitting.

10 CORONA TEST

Typical insulator sets completely assembled with all fittings shall be set up in a manner as nearly as possible to the arrangement to be used. A test voltage of 160kV, 100kV and 50kV shall be applied for the nominal voltage of 220kV, 132kV and 66kV respectively between the conductor and earth for five minutes during which time no corona formation shall be visible or audible with the room in complete darkness.

11 VISUAL EXAMINATION

The test samples shall be examined visually for the following defects:

Visual Examination

Examination	Defects
Material	Not as specified in relevant clauses.
Construction	Not of the shape given in relevant Dwg. Any part missing.
Finish	Galvanising not proper. Presence of burrs, black and bare spots, dross and projections, which will interfere with proper use of the articles.

12 VERIFICATION OF DIMENSIONS

The binding dimensions of the hardware shall be measured and shall be as shown on the relevant approved drawings subject to the tolerance given in clause 5.

13 GALVANISING TEST

This test shall be carried out on all ferrous parts complying with the following requirements:

i. Weight of zinc coating

ii. Uniformity of zinc coating

iii. Adherence of zinc coating

This test shall be performed in accordance with WAPDA Specification P-82:81 (latest revision)

14 SAMPLING PLAN --ACCEPTANCE AND REJECTION

I. Sampling sizes are designated by code letters. Table-III shall be used to find the applicable code letter for the particular lot or batch size for various tests specified in this specification. While the number of units of product from each lot or batch which are to be inspected (sample size) & the criteria for determining the acceptability of the lot or batch (acceptance & rejection numbers) for different code letters can be obtained from the table-IV given below.

II. The number of sample units inspected shall be equal to the first sample size given in Table-IV. If the number of defective units found in the first sample is equal to or less than the first acceptance number, the lot shall be acceptable. If the number of defectives found in the first sample is equal to or greater than the first rejection number, the lot shall be rejected. If the number of defectives found in the first sample is between the first acceptance and rejection number, a second sample of the size given by the plan shall be inspected. The number of defectives found in the first & the second samples shall be accumulated. If the cumulative number of defectives is equal to or less than the second acceptance number, the lot shall be acceptable. If the cumulative number of defectives is equal to or greater than the second rejection number, the lot shall be rejected.

Table-III Sample Size

Lot or Batch Size	Sample size for Test Specified in Clause 8,9, & 13.	Sample size for dimensional and finish defects
2 to 8	A	A
9 to 15	A	B
16 to 25	A	C
26 to 50	A	D
51 to 90	B	E
91 to 150	B	F
151 to 280	B	G
281 to 500	B	H
501 to 1200	C	J

Table-IV Sample Acceptance Criteria

Sample size code letters	Sample	Sample size	Cumulative sample size	Acceptance Number	Rejection Number
1	2	3	4	5	6
A	First	1	1	0	1
	Second	-	-	-	-
B	First	2	2	0	2
	Second	2	4	1	2
C	First	3	3	0	2
	Second	3	6	1	2
D	First	5	5	0	2
	Second	5	10	1	2
E	First	8	8	0	2
	Second	8	16	1	2
F	First	13	13	0	3
	Second	13	26	3	4
G	First	20	20	1	4
	Second	20	40	4	5
H	First	32	32	2	5
	Second	32	64	6	7
J	First	50	50	3	7
	Second	50	100	8	9

15 MARKING AND PACKING

The material shall be packed in wooden crates for export shipment to permit convenient handling and to protect against loss or damage to final destination. Containers (wooden crates) shall be designed for handling by forklifts, trucks and by slings around the containers. The weight of each package should be between 100 and 150 Kg.

Packages shall be designed for rough handling. All wooden crates shall be clearly marked to indicate.

1. Quantity
2. Name of hardware item
3. Manufacturer's name

All packages shall be numbered consecutively so that total shipment can be readily determined.

16 INFORMATION TO BE SUPPLIED

The following information shall be supplied with the bid and failure to supply the same may subject the bid to disqualifications:

i. Detailed fully dimensioned drawings of hardware for suspension strings.

ii) Specification giving material grade & composition of all items of hardware.

iii) Catalogues/literature of standardised items.

iv) Test certificates.

v) One complete sample of hardware for all types of suspension strings.

vi) Detail of manufacturing & testing facilities available with manufacturers.

17 . DRAWINGS

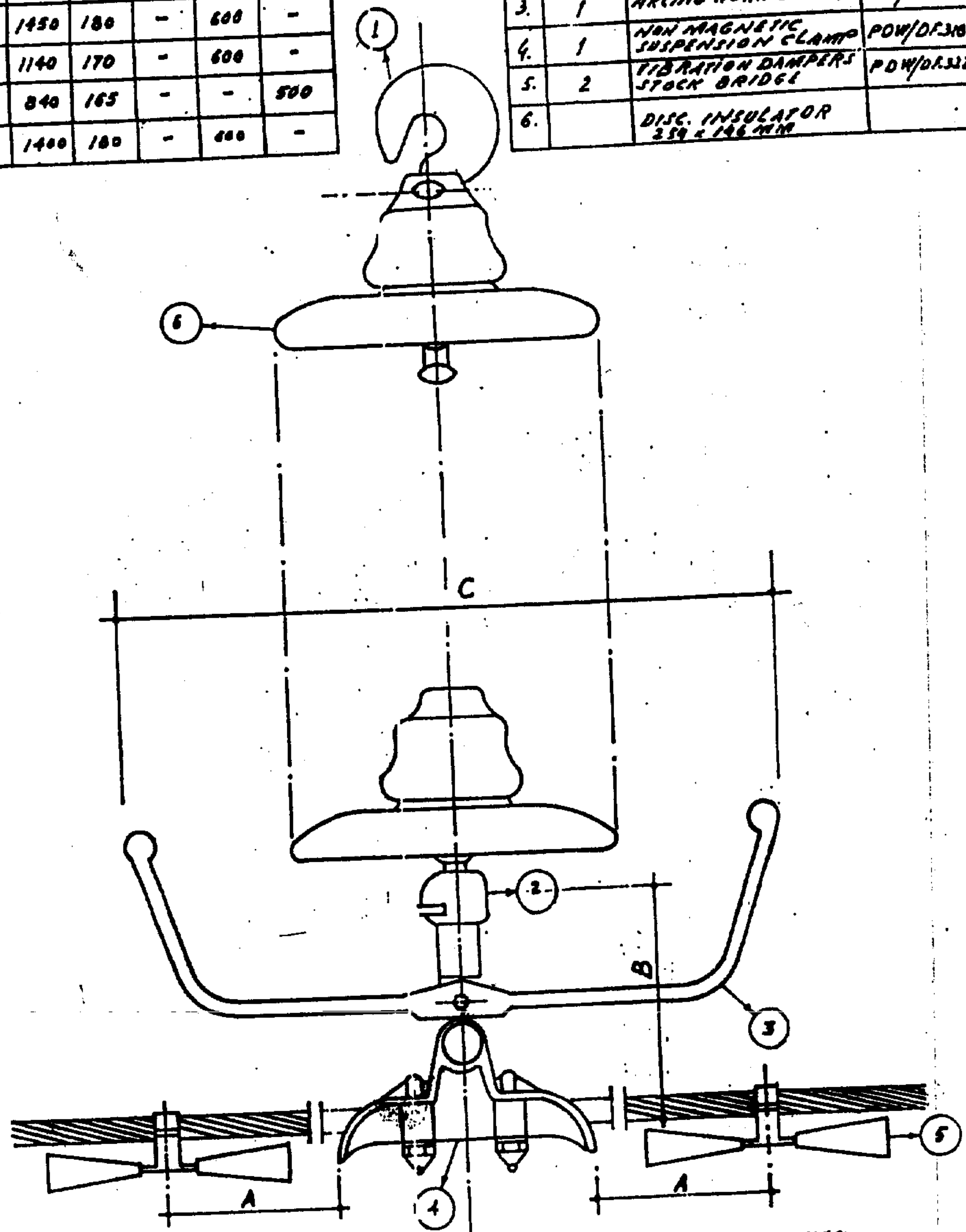
The following drawings form the part of this specification:

a)	Single Suspension String	PDW/DF-314
b)	Self Locking Ball Hook	PDW/DF-315
c)	Socket Eye	PDW/DF-316
d)	Arcing Horns	PDW/DF-317
e)	Suspension Clamp for ACSR Conductors	PDW/DF-318
f)	Socket Clevis Type A	PDW/DF-376
g)	Yoke Plate	PDW/DF-377
h)	Ball Clevis	PDW/DF-382
i)	Socket Clevis Type B	PDW/DF-378
j)	Eye Clevis	PDW/DF-379
k)	Double Suspension String	PDW/DF-381

yk

CONDUCTOR DESIGNATION	DIMENSIONS A	B	C 220 KV	132 KV	66 KV
RAIL	1525	180	750	600	-
CUCKOO	1450	180	-	600	-
LYNX	1140	170	-	600	-
DOG	840	165	-	-	500
CARDINAL	1400	180	-	600	-

ITEM	QTY.	DESCRIPTION	DRG. NO.
1.	1	SELF LOCKING BALL HOOK	PDW/DF-315
2.	1	SOCKET EYE	PDW/DF-316
3.	1	ARCING HORN BOTTOM	PDW/DF-317
4.	1	NON MAGNETIC SUSPENSION CLAMP	PDW/DF-318
5.	2	VIBRATION DAMPERS STOCK BRIDGE	PDW/DF-322
6.		DISC. INSULATOR 254 x 146 MM	



DIMENSION SHOWN IN MILLIMETRES

1	20-9.82	DIMENSION FOR ACSR CARDINAL CONDUCTOR ADDED

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY

DESIGN DEPARTMENT

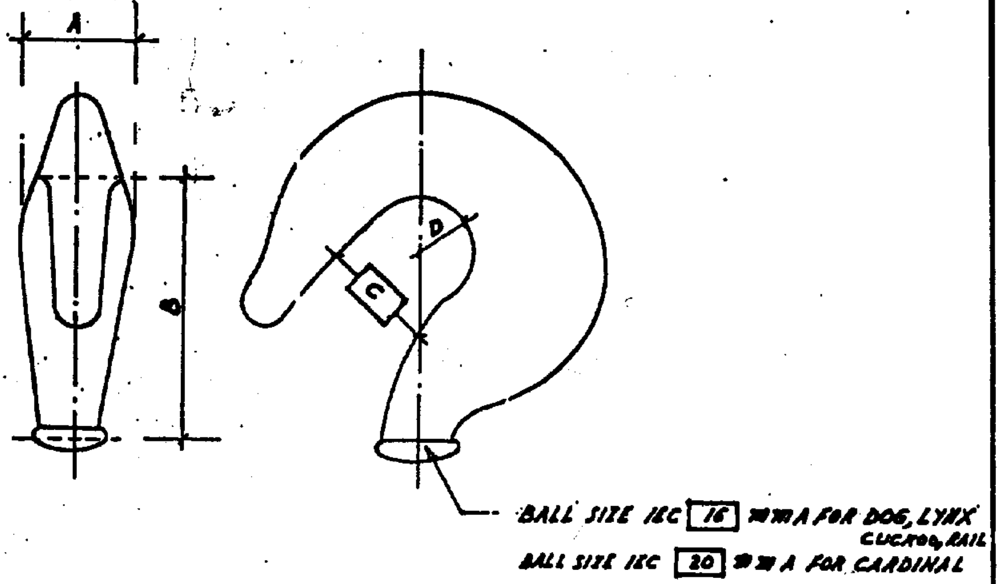
DRAWN	AZHAR SHAH	
CHECKED	GHULAM RASUL	
JUNIOR ENGINEER	NAZAR ABBAS	
SENIOR ENGINEER	MUNAWAR-A-MALIK	
DIRECTOR	S. ISHTIAQ HUSSAIN	
CHIEF	...VID AKHTER	

SINGLE SUSPENSION STRING

SCALE ✓

DATE 27-9.80

DWG. NO. PDW/DF-314



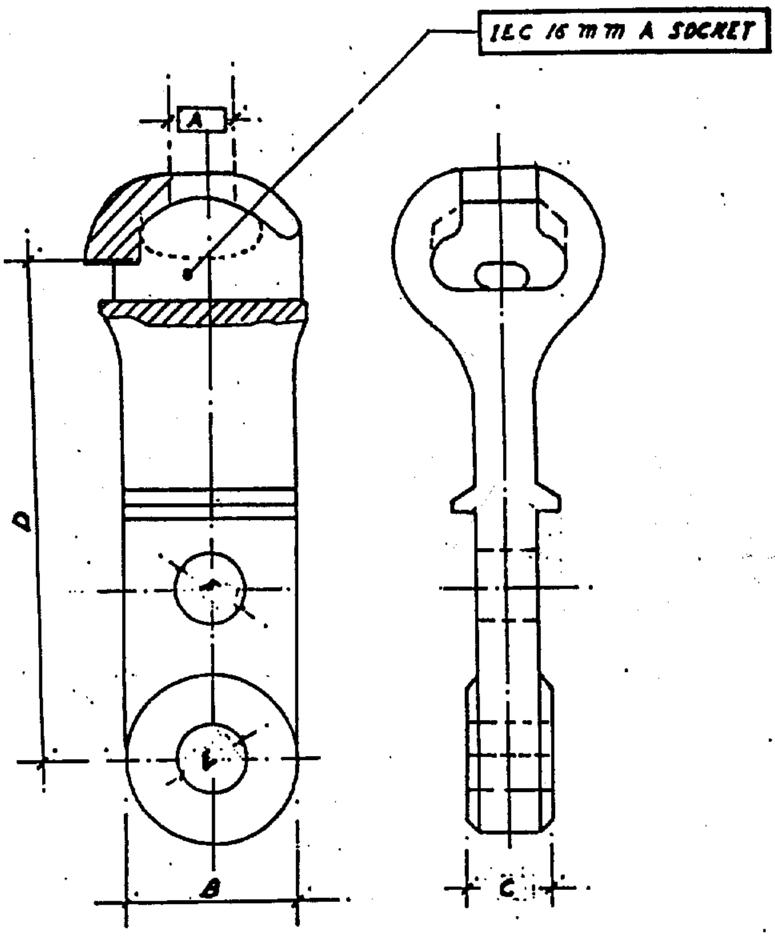
DESCRIPTION	A	B	C	D
SELF LOCKING BALL HOOK	30	60	22	14

☐ INDICATES BINDING DIMENSION.

DIMENSION SHOWN IN MILLIMETRES

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY			DESIGN DEPARTMENT
DRAWN	AZHAR SHAH		SELF LOCKING BALL HOOK
CHECKED	GHULAM RASUL	Grasul	
JUNIOR ENGINEER	NISAR ABBAS		
SENIOR ENGINEER	MUHAMMAD-A-MALIK		
DIRECTOR	S. ISHTIAQ HUSSAIN		SCALE / DATE 27.9.80
CHIEF ENGINEER	JAVID AKHTER		DWG: NO. PDW/DF315

NO	DATE	REVISIONS	BY
1	2-3-82	BALL SIZE FOR ACSR CARDINAL CONDUCTOR ADDED	



SOCKET EYE

DESCRIPTION	A	B	C	D	E	F
DOG & LYNX	16	44.5	22	110	17.5	14
CUCKOO & RAIL	16	44.5	35	110	17.5	14
CARDINAL	20	445	35	110	17.5	14

▭ INDICATES BINDING DIMENSION

DIMENSION SHOWN IN MILLIMETRES

1	3.9.82	DIMENSIONS FOR ACSR CARDINAL ADDED.	
		REVISIONS	BY

PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY
DESIGN DEPARTMENT

DRAWN	AZHAR SHAH	
CHECKED	GHULAM RASUL	Ghulam Rasul
JUNIOR ENGINEER	NAZIR ABBAS	Nazir Abbas
SENIOR ENGINEER	MUNAWAR-A-MALIK	
DIRECTOR	S. ISHTIAQ HUSSAIN	
CHIEF	JAVID AKHTER	

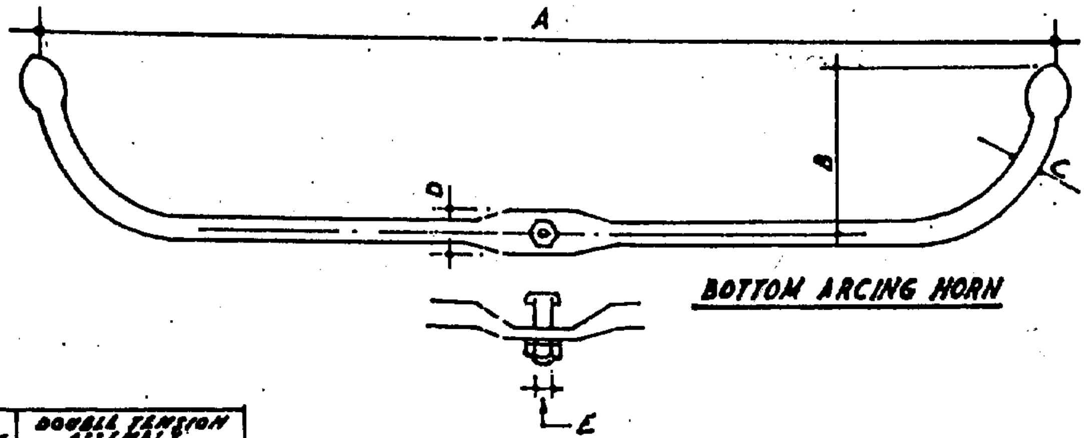
SOCKET EYE
(FOR SUSPENSION STRING)

SCALE ✓ DATE 27.9.80

DWG. NO PDW/DE-316

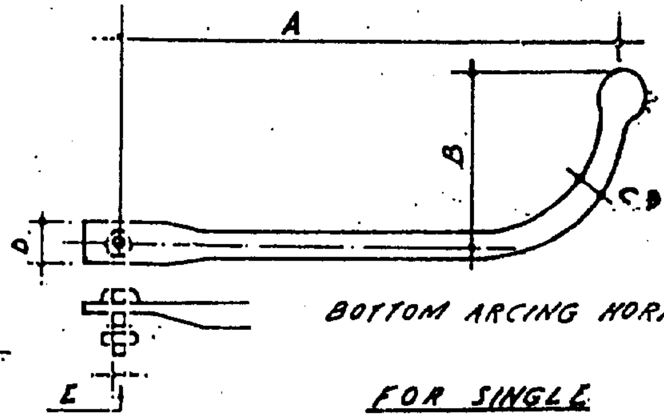
FOR SINGLE SUSPENSION ASSEMBLY

VOLTAGE KV	SINGLE SUSPENSION ASSEMBLY					SINGLE TENSION / DOUBLE SUSPENSION ASSEMBLY				
	A	B	C	D	E	A	B	C	D	E
66	500	110	14	30	12	250	110	14	30	12
132	600	120	14	30	12	300	120	14	30	12
220	750	125	18	30	12	375	125	18	30	12



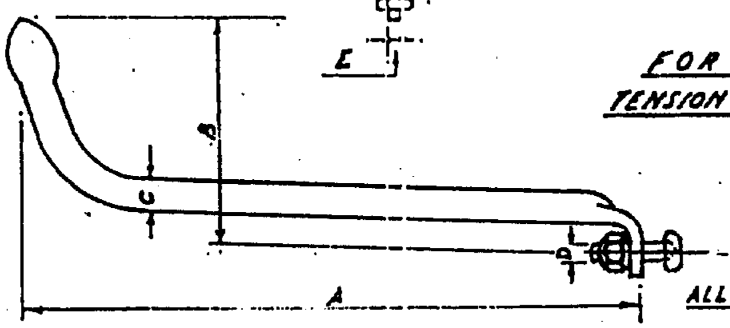
BOTTOM ARCING HORN

VOLTAGE	DOUBLE TENSION ASSEMBLY			
	A	B	C	D
66 KV	245	115	14	12
132 KV	295	125	16	12
220 KV	370	140	18	12



BOTTOM ARCING HORN

FOR SINGLE TENSION ASSEMBLY



ALL DIMENSION IN MILLIMETRES

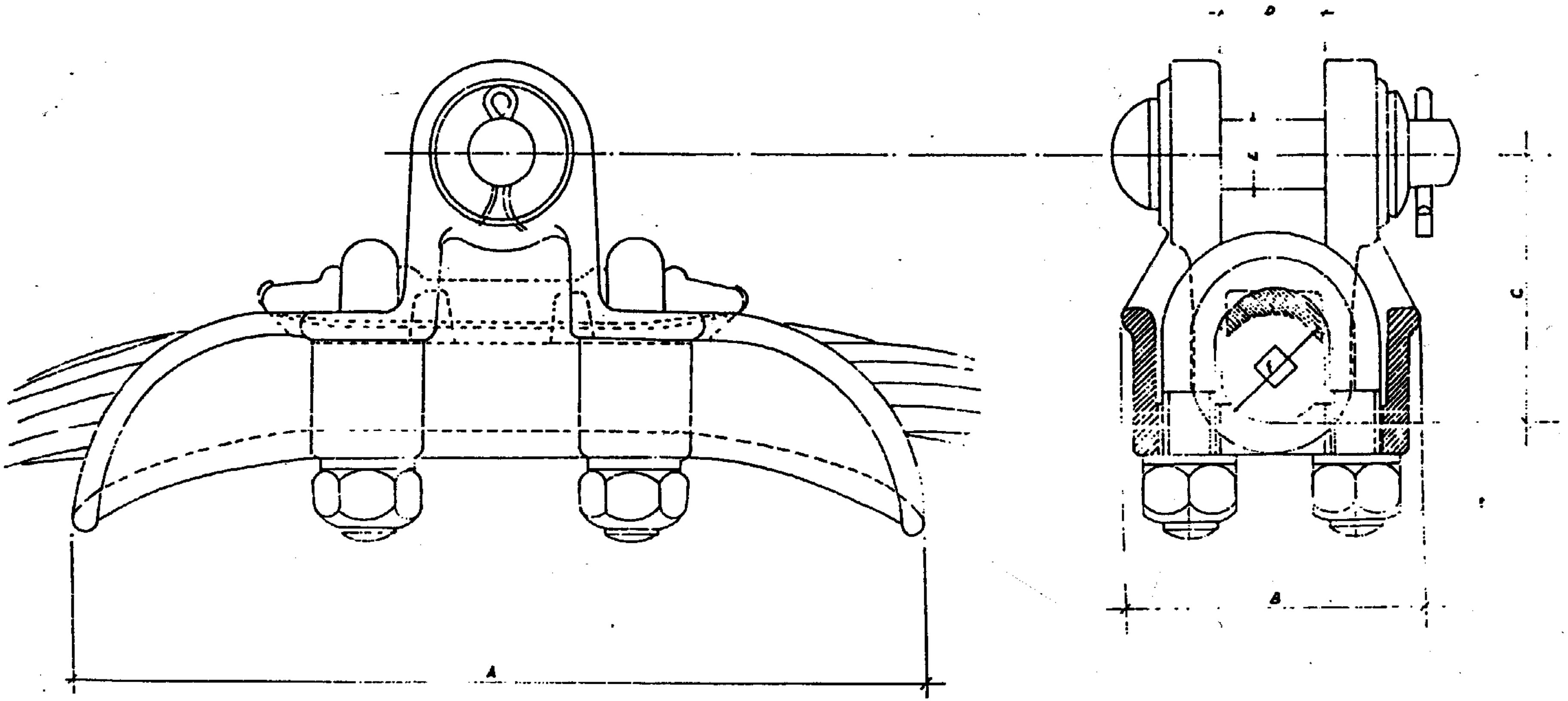
FOR DOUBLE TENSION ASSEMBLY BOTTOM ARCING HORN

1	9-9-82	BOTTOM ARCING HORN DOUBLE TENSION ASSEMBLY ADDED

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY			DESIGN DEPARTMENT
DRAWN	AZHAR SHAH		ARCING HORNS
CHECKED	GHULAM RASUL	Grasul	
JUNIOR ENGINEER	NAZAR ABBAS		
SENIOR ENGINEER	MUNAWAR-A-MALIK		SCALE
DIRECTOR	S. ISHTIAQ HUSSAIN		DATE 27-9-80

DWG. No. DDW/DE 317

37



DIMENSION SHOWN IN MILLIMETRES

☐ INDICATES BINDING DIMENSION

DESCRIPTION	A	B	C	D	E	F
DOG	180	62	55	24	16	14.2
LYNX	190	65	60	24	16	19.5
CUCKOO	220	87	70	37	16	27.7
RAIL	226	87	70	37	16	29.6
CARDINAL	210	87	70	37	16	30.4

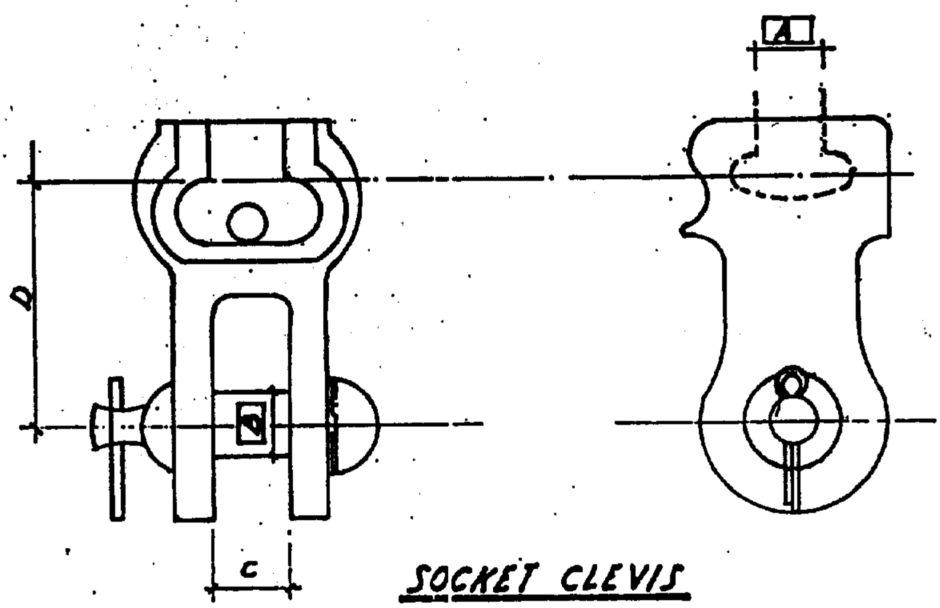
NO	DATE	REVISIONS	BY
1	2-9-82	DIMENSIONS FOR ACSR CARDINAL ADDED	

PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY
DESIGN DEPARTMENT

DRAWN	AZHAR SHAH	
CHECKED	GHULAM RASUL	
JUNIOR ENGINEER	NAZAR ABBAS	
SENIOR ENGINEER	MUHAMMAD-A-MAILK	
DIRECTOR	S. ISHTIAQ HUSSAIN	
CHIEF ENGINEER	JAVID AKHTER	

SUSPENSION CLAMP
FOR ACSR CONDUCTORS

SCALE
DATE 27-9-80
DWG: NO. PDW/DF-318



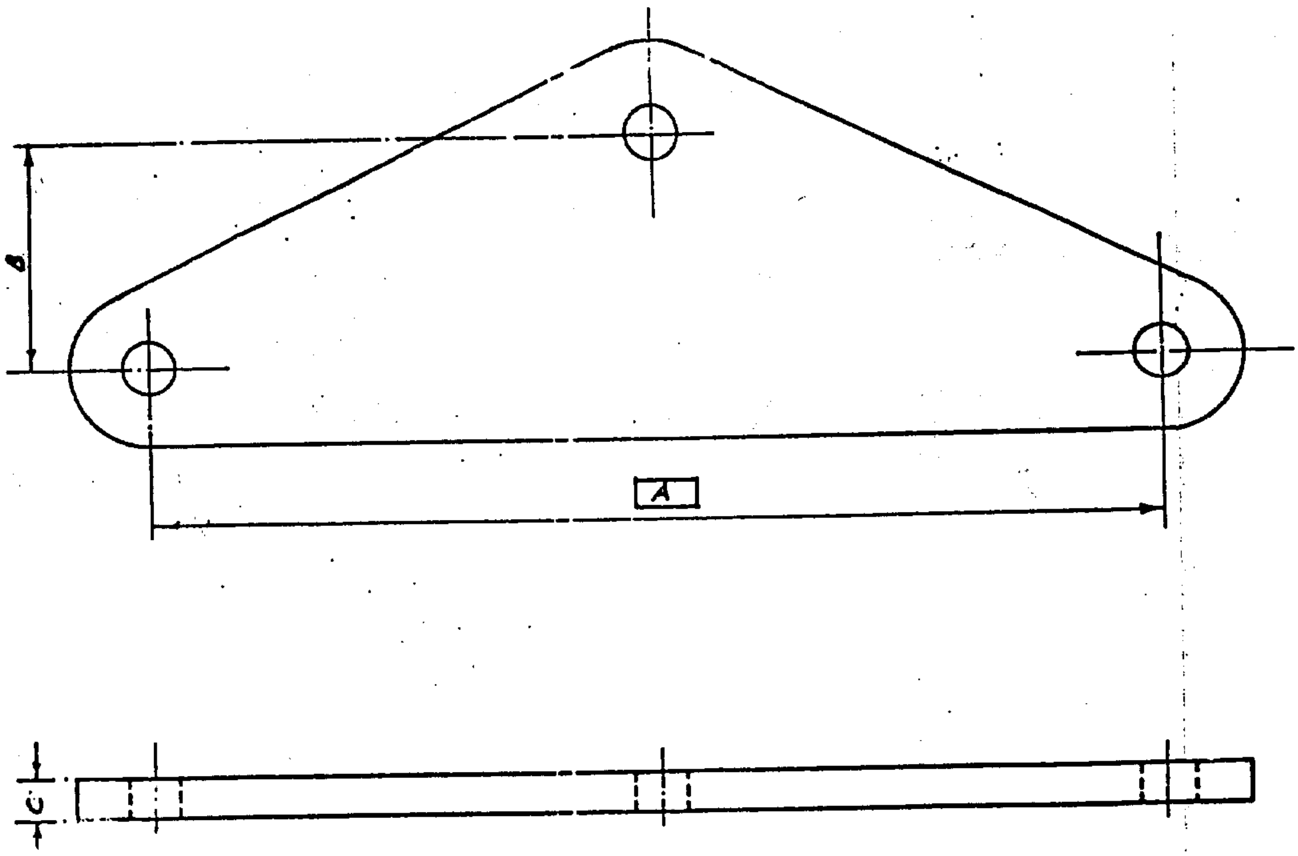
SOCKET CLEVIS
TYPE - A

DESCRIPTION	DIMENSIONS			
	A	B	C	D
DOG, LYNX	16	16	18	70
CUCKOO, RAIL	16	16	20	70
CARDINAL	20	16	20	70

DIMENSIONS SHOWN IN MILLIMETRES

☐ INDICATES BINDING DIMENSIONS

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY			DESIGN DEPARTMENT
DRAWN	AZHAR SHAN		SOCKET CLEVIS TYPE - A
CHECKED	GHULAM RASUL		
ASST. DIRECTOR	NAZAR ABBAS		
DEPUTY DIRECTOR	MUNAWAR-A-MALIK		
DIRECTOR	S. ISHTIAQ HUSSAIN		SCALE ✓ DATE 13-9-82
CHIEF ENGINEER			DWG. NO. PDW/DF-376

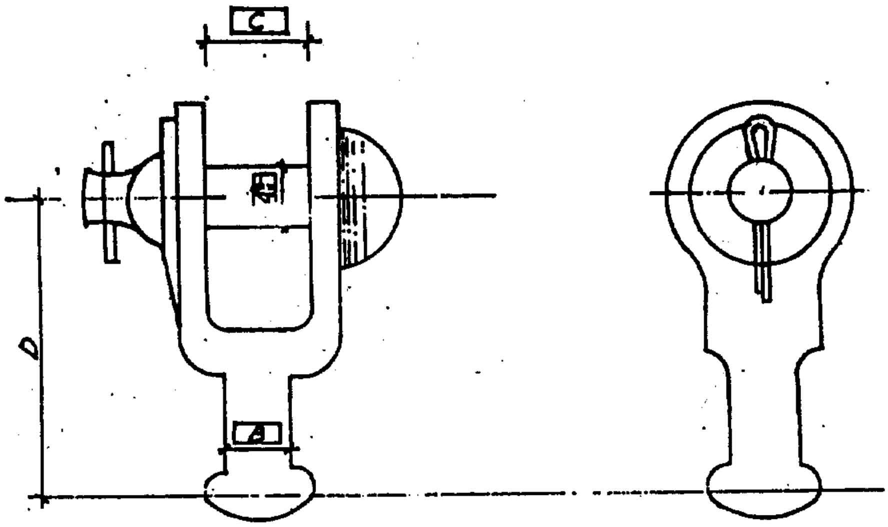


DESCRIPTION	A	B	C
DOG, LYNX	400	90	16
CUCKOO, RAIL CARDINAL	400	90	18

ALL DIMENSIONS IN MILLIMETRES

☐ INDICATES BINDING DIMENSIONS

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY			DESIGN DEPARTMENT POWER	
DRAWN	AZHAR SHAH		YOKE PLATE	
CHECKED	GHULAM RASUL			
ASSTT DIRECTOR	NAZAR ABBAS			
DEPUTY DIRECTOR	MUNAWAR-A-MALIK			
DIRECTOR	S. ISHTIAQ HUSSAIN		SCALE ✓	DATE. 13-9-82
CHIEF ENGINEER			DWG: NO. PDW/DF-377	



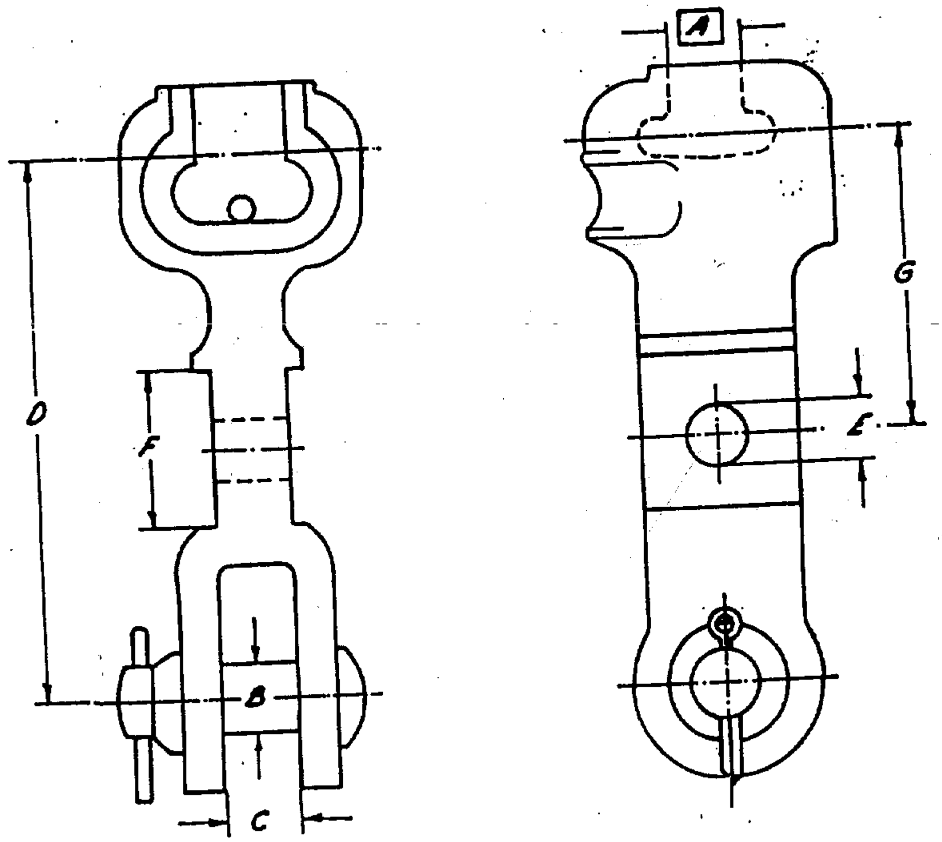
BALL CLEVIS

DESCRIPTION	DIMENSIONS			
	A	B	C	D
DOG, LYNX	16	16	18	75
CUCKOO, RAIL	16	16	20	75
CARDINAL	16	20	20	75

DIMENSION SHOWN IN MILLIMETRES

☐ INDICATES BINDING DIMENSIONS

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY			DESIGN DEPARTMENT
DRAWN	AZHAR SHAH		BALL CLEVIS
CHECKED	GHULAM RASUL		
ASSTT DIRECTOR	NAZAR ABBAS		
DEPUTY DIRECTOR	MUNAWAR-A-MALIK		
DIRECTOR	S. ISHTIAQ HUSSAIN		SCALE ✓ DATE 13-9-82
CHIEF ENGINEER			DWG: NO. PDW/DF-382



SOCKET CLEVIS
TYPE- B

DESCRIPTION	A	B	C	D	E	F	G
DOG, LYNX	16	16	18	110	14	30	60
CUCKOO, RAIL	16	16	20	110	14	30	60
CARDINAL	20	16	20	110	14	30	60

DIMENSION SHOWN IN MILLIMETERS.

[ ] INDICATES BINDING DIMENSIONS

PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY

DESIGN DEPARTMENT (POWER)

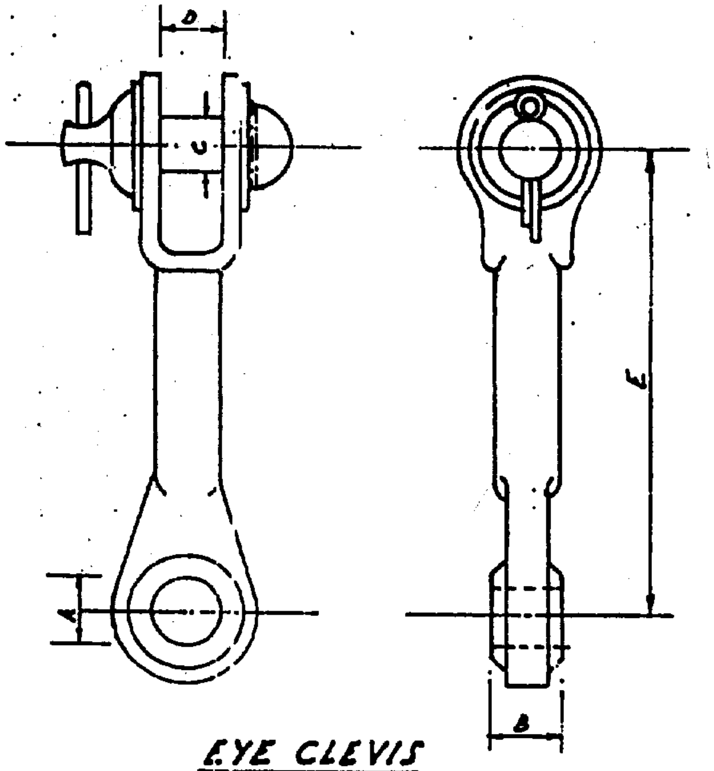
DRAWN	IJAZ AHMOOD	
CHECKED	A. LATIF	
JUNIOR ENGINEER	NAZAR ABBAS	
SENIOR ENGINEER	MUNAWAR A. MALIK	
DIRECTOR	S. ISHTIAQ HUSSAIN	
CHIEF		

SOCKET CLEVIS
TYPE - B

SCALE:- ✓

DATE:- 13-9-82

DWG NO PDW/DF- 378



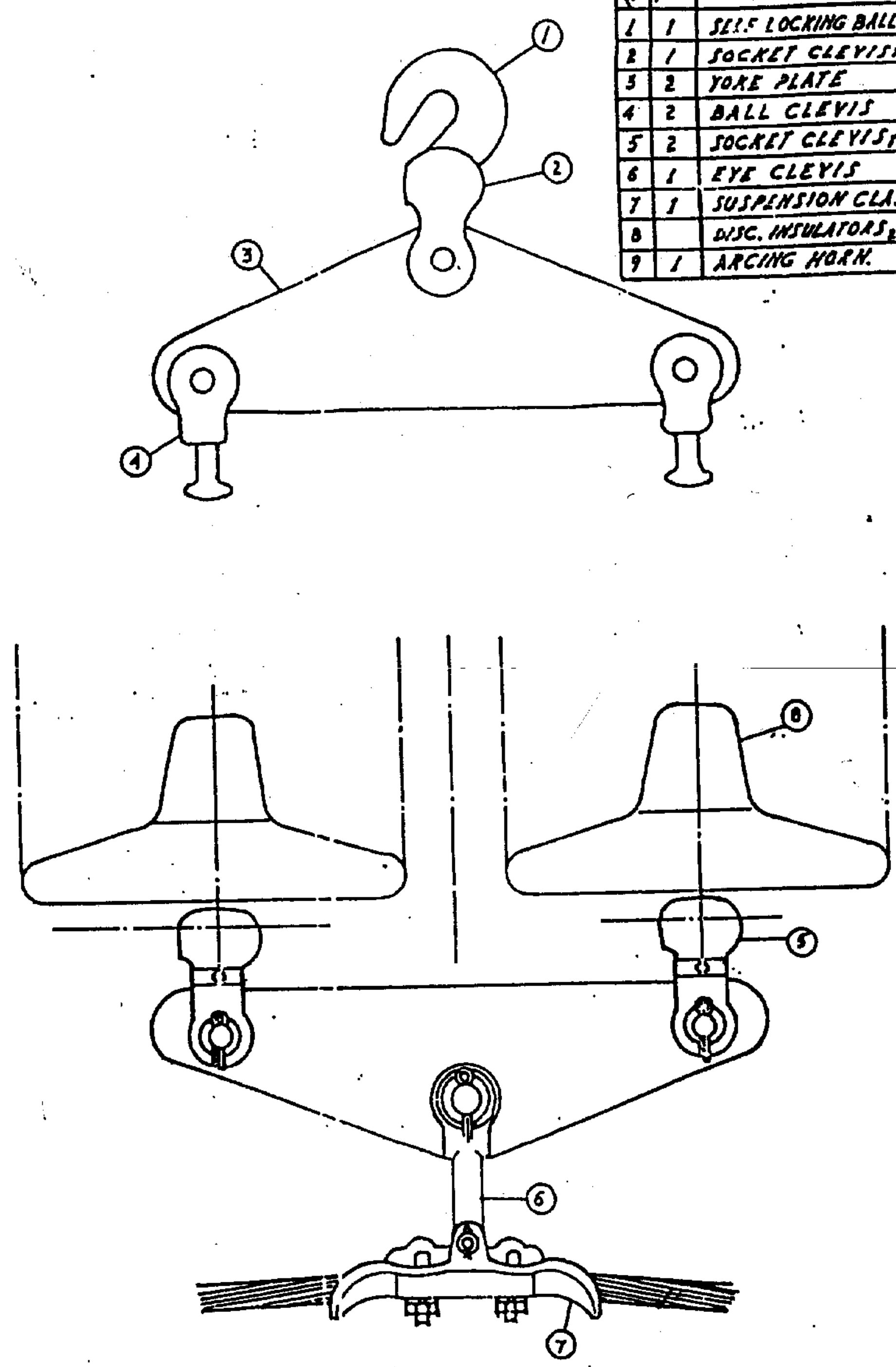
EYE CLEVIS

DESCRIPTION	A	B	C	D	E
DOG, LYNX	18	22	16	18	80
CUCKOO, RAIL CARDINAL	18	35	15	20	80

ALL DIMENSION IN MILLIMETRES

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY			DESIGN DEPARTMENT POWER
DRAWN	AZHAR ALI SHAH		EYE CLEVIS WITH 90° EYE
CHECKED	GHULAM RASUL		
JUNIOR DIRECTOR	NAZAR ABBAS		
DEPUTY DIRECTOR	MUNAWAR-A-MALIK		
DIRECTOR	S. ISHTIAQ HUSSAIN		SCALE ✓ DATE 13-9-82
CHIEF ENGINEER			DWG: NO. PDW/DF-379

ITEM	QTY	DESCRIPTION	DWG. NO.
1	1	SELF LOCKING BALL HOOK	PDW/DF-315
2	1	SOCKET CLEVIS TYPE-A	PDW/DF-376
3	2	YOKE PLATE	PDW/DF-377
4	2	BALL CLEVIS	PDW/DF-382
5	2	SOCKET CLEVIS TYPE-B	PDW/DF-378
6	1	EYE CLEVIS	PDW/DF-379
7	1	SUSPENSION CLAMP	PDW/DF-318
8		DISC. INSULATORS 254×146	—
9	1	ARCING HORN.	PDW/DF-317



PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY			DESIGN DEPARTMENT
DRAWN	AZHAR SHAH		DOUBLE SUSPENSION STRING
CHECKED	GHULAM RASUL		
ASSTT. DIRECTOR	NAZAR ABBAS		
DEPUTY DIRECTOR	MUNAWAR-A-MALIK		
DIRECTOR	S. ISHTIAQ HUSSAIN		SCALE ✓ — DATE 13-9-82
CHIEF ENGINEER			DWG: NO. PDW/BF-381

SPECIFICATION P-143:82

TENSION STRINGS

PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY
DESIGN DEPARTMENT (POWER)

BLANK

SPECIFICATION P-143:82

TENSION STRINGS

0. FOREWORD

0.1 This standard has been introduced by WAPDA and has been prepared by the Transmission Line Section of the Office of the Chief Engineer (Design).

0.2 This standard is intended only for the purpose of technical specification to facilitate procurement of materials and does not include provision of contract.

0.3 This specification is subject to periodic revision as and when required.

1 SCOPE

1.1 This specification covers the hardware of tension strings for Transmission Lines and Substations.

2 TYPES OF TENSION STRINGS

2.1 Tension Strings described in this Specification are of the following types:

TABLE I

Description	String Designation	Conductor OD(mm)
a) Single Tension string for 'DOG.	ST-D	14.2
b) Single Tension string for 'LYNX'.	ST-L	19.5
c) Single Tension string for 'CUCKOO'.	ST-C	27.7
d) Single Tension string for 'RAIL'.	ST-R	29.6
e) Single Tension string for 'CARDINAL'.	ST-CA	30.4
f) Single Tension string for 'ARBUTUS'.	ST-A	26.1
g) Single Tension string for 'HAWTHORN'.	ST-H	31.9

h) Double Tension string for 'DOG'.	DT-D	14.2
i) Double Tension string for 'LYNX'.	DT-L	19.5
j) Double Tension string for 'CUCKOO'.	DT-C	27.7
k) Double Tension string for 'RAIL'.	DT-R	29.6
l) Double Tension string for 'CARDINAL'.	DT-CA	30.4

2.2 The hardware used in the tension string described above in this Specification has been designated by code numbers. These codes have been assigned in the following manner:

i) The first letter 'S' stands for single and 'D' for Double.

ii) The next letter 'T' stands for tension.

iii) The succeeding letters stand for the name of conductor for which the hardware is meant for i.e. "D" for Dog; "L" for LYNX; "C" for CUCKOO, "R" for RAIL, "CA" for CARDINAL, "A" for ARBUTUS, and "H" for HAWTHORN.

3 RATINGS OF HARDWARE

3.1 The hardware shall be of the ratings as specified in Table-II and Table III below:

TABLE -II

RATINGS OF HARDWARE FOR SINGLE TENSION STRING

Sr. No.	Description	Failing Load(Kg)					
		ST-D	ST-L	ST-C	ST-R	ST-A	ST-H
1.	Ball Hook	8000	8000	12000	12000	8000	9000
2.	Socket Eye	8000	8000	12000	12000	8000	9000
3.	Arcing Horn	150	150	150	150	150	150
4.	Shackle	-	-	12000	12000	12000	12000
5.	Tension Clamp						
	i) Bolted type	8000	8000	-	-	-	-
	ii) Compression type.	-	-	12000	12000	8000	9000

1 Arcing Horn Bottom
1 Tension Clamp.

4.3 The ball and socket shall be of size IEC 16 shall conform to WAPDA Specification P-8 (latest revision)

4.4 All ferrous parts shall be hot dip galvanized in accordance with WAPDA Specification P-82(Latest revision).

4.5 The coupling parts of hardware that mate with each other, shall not have a play of more than 2 mm.

5 DIMENSIONS AND TOLERANCES

All hardware shall generally be in accordance with drawings forming a part of this Specification.

The dimensions of these parts of hardware that mate with other hardware or that determine the length of insulator string are binding and are shown enclosed on the drawings.

For dimensions that are fixed and binding the tolerance will be plus or minus 2 percent with a maximum of 0.8 mm. For dimensions that are shown as MAX or MIN there shall be no plus and minus tolerance respectively. The tolerance in the opposite sense may however be 4%.

6 DESIGN AND MATERIAL

6.1 Self Locking Ball Hook

It shall be made from drop forged steel of suitable grade and shall be hot dip galvanised. The detail dimensions shall be according to Dwg.No. PDW/DF-315.

6.2 Socket Eye

It shall be made from drop forged steel or malleable iron of suitable grade. It shall be hot dip galvanised. The detail dimension shall be according to Dwg.No. PDW/DF-332. It shall be supplied with a split pin made from half round brass wire protected against corrosion by appropriate coating and shall be able to work under hot line conditions.

6.3 Socket Clevis

These shall be made from drop forged steel or malleable iron of suitable grade. These shall be hot dip galvanised and shall meet according to dwg.Nos.PDW/DF-376 & [illegible]

TABLE -III

.TINGS OF HARDWARE FOR DOUBLE TENSION STRING

.iption	Failing Load(Kg) DT-D	DT-L	DT-C	DT-R	DT-CA
.11 Hook	12,000	12,000	20,000	20,000	25,000
ocket Clevis Type 'A'	12,000	12,000	20,000	20,000	25,000
Yoke Plates	12,000	12,000	20,000	20,000	25,000
Ball Clevis	8,000	8,000	12,000	12,000	16,000
Socket Clevis Type 'B'	8,000	8,000	12,000	12,000	16,000
). Eye Clevis	12,000	12,000	20,000	20,000	25,000
7. Shackle	-	-	20,000	20,000	25,000
8. Arcing Horn Bottom.	150	150	150	150	150
9. Tension Clamp.					
i) Bolted Type	8,000	8,000	-	-	-
ii) Compression Type	-	-	12,000	12,000	16,000

4 GENERAL REQUIREMENTS

4.1 Each Single tension string hardware for Transmission Line and grid station shall consist of the following items:

1. Self locking Ball Hook
1. Socket Eye
1. Arcing Horn (Bottom)
1. Shackle (with compression type clamp only)
1. Tension Clamp

4.2 Each Double tension string hardware for Transmission Line and grid station shall consist of the following items;

1. Self locking Ball Hook
1. Socket Clevis Type 'A'
2. Yoke Plates.
2. Ball Clevis.
2. Socket Clevis Type 'B'
1. Eye Clevis (with Bolted type clamp only)
1. Shackle (with compression type only)

The socket shall be supplied with a split pin made from half round brass wire protected against corrosion by an appropriate coating and shall be able to work under hot line conditions. The clevis shall be supplied with rivet round headed with aluminium alloy round washer and straight split pin. The split pin shall be made from cadmium plated brass or copper.

6.4 Yoke Plates

Yoke plates shall be of mono block or flat type and shall be made from high grade steel, hot dip galvanized and subject to normalizing process and shall be made according to Drawing No. PDW/DF-377.

6.5 Ball Clevis

It shall be made from drop forged steel of suitable grade and shall be hot dip galvanized. It shall be made according to Drawing No. PDW/DF-382.

6.6 Arcing Horn

It shall be made from drop forged mild steel and shall be hot dip galvanized. The dimensions shall be according to Dwg.No. PDW/DF-317. The tolerance on the length will be 5% with a maximum of 15mm.

6.7 Eye Clevis

It shall be made from drop forged steel of suitable grade and shall be hot dip galvanised. The detail dimensions shall be according to Dwg.No. PDW/DF-379. The clevis shall be supplied with rivet round headed with aluminum alloy round washer and straight split pin. The split pin shall be made from cadmium plated brass or copper.

The eye shall be supplied with a split pin made from half round brass wire protected against corrosion by an appropriate coating and shall be able to work under hot line conditions.

6.8 Shackle

These shall be made from forged steel, hot dip galvanised and shall be according to Dwg.No.PDW/DF-331..

6.9 Tension Clamps

The tension or dead end clamps shall be so designed that they meet the requirements of the following tests and that the effect of vibration, both on the conductors and on the fitting itself are minimised. Tension clamps shall be of bolted type and compression dead end type as described below:

Conductor Tension Clamp for ACSR Conductors(Bolted Type)

The tension clamp for LYNX and DOG shall be of the bolted type and shall be made of forged high strength corrosion resistant aluminium alloy. Bolts shall be made of hot dip galvanised steel. Cotter pins shall be made of stainless steel. The tension clamp shall be made according to Dwg.No. PDW/DF-328.

Conductor Tension Clamp for ACSR Conductors (Compression Type)

The tension clamp for RAIL, CUCKOO and CARDINAL shall be of compression dead end type. It shall be composed of aluminimum body with one jumper lug, one galvanised steel terminal and one aluminimum jumper terminal with galvanised steel bolts. The aluminimum jumper terminal shall be at 30^0 and shall be supplied with bolts, nuts, aluminimum alloy washers and spring washers.

The clamp when assembled shall be capable of developing not less than 96% of the rated minimum failing load as specified in Table I & III and has conductivity not less than that of conductor. The clamp shall be made according to Dwg.No. PDW/DF-301.

Conductor Tension Clamps for All Aluminimum Conductor (Compression Type)

The tension clamp for aluminimum conductor namely, Arbutus and Hawthorn shall be of compression dead end type. It shall be composed of aluminimum body and one galvanised steel terminal without tubular termination. The clamp when assembled shall be capable of developing not less than 96% of the rated minimum failing load as specified in Table-II, and has conductivity not less than that of conductor. The clamp shall be made according to Dwg.No. PDW/DF-329.

7 TESTS

7.1 Type Tests

7.1.1 Type tests are intended to verify and establish design characteristics. They shall be made once only on hardware identical in all essential details with those to be supplied.

The following type tests shall be carried out in accordance with clause 10,11,12.13, and 14.

i)	Mechanical Test	On each individual item of hardware.
ii)	Resistance to Conductor Slippage Test	On tension clamp only.
iii)	Heat Cycle Test	On compression type tension clamp only.
iv)	Resistance Test	On compression type tension clamp only.
v)	Corona Test	For complete insulator string.

7.1.2 The Contractor shall supply heat cycle test results with the bid.

7.2 Sample Tests

Sample tests shall be made to verify the quality and workmanship.

The following sample tests shall be performed in accordance with clause 8, 9, 10, 11, 13 and 15.

i)	Visual Examination	On each item of hardware
ii)	Verification of dimensions	
iii)	Mechanical Test	
iv)	Resistance to Conductor Slippage Test	On tension clamp only.
v)	Resistance Test	On compression type tension clamp only.
vi)	Galvanising Test	On all ferrous parts

8 VISUAL EXAMINATION

The test samples shall be examined visually for the following defects.

Visual Examination

Examination	Defects
Material	Not as specified in relevant clauses
Construction	Not of the shape given in relevant Dwg. Any part missed.
Finish	Galvanising not proper. Presence of burrs, black and bare spots, dross and projections, which will interfere with proper use of the articles

9 VERFICIATION OF DIMENSIONS

The binding dimensions of the hardware shall be measure-ed and shall be as shown on the relevant approved drawings subject to the tolerance given in clause 5.

10 MECHANICAL TEST

10.1 For Hardware Except Arcing Horn

The fitting shall be held in tensile testing machine in a manner approximating as nearly as possible to the arrangement to be used in service. A tensile load equal to one half of the specified minimum failing load shall be applied and increased at a steady rate. Failure of the fitting shall not occur at a load less than the specified minimum failing load as per Table-II and Table-III.

10.2 For Arcing Horn

Arcing horn shall be rigidly supported in a manner approximating as nearly as possible to the arrangement in service and a load of 150 Kg shall be applied parallel to the insulator string axis at each outer extremity of the fitting. The fitting shall not fail or show any signs of distortion of over-stressing of the material.

11 RESISTANCE TO CONDUCTOR SLIPPAGE TEST

Test piece shall be assembled in accordance with manufacturer's recommendations on conductors of the size and type with which it is to be used. The assembly shall be mounted in a tensile testing machine and anchored in a manner approximating as nearly as possible to the arrangement to be used in service, precautions being taken to avoid birdcaging of the conductor. The length of conductor joint in the test assembly should preferably be not less than 100 times the overall diameter of the conductor.

A tensile load of about 50% of the minimum failing load as specified in Table-II and Table-III shall be applied and the conductor shall be marked in such a way that movement relative to the fitting can easily be detected, without any subsequent adjustment of the fitting, the load shall be steadily increased to 95% of the minimum failing load and then reduced to 90% of the minimum failing movement of the conductor relative to the fitting due to slip during this 1 minute period and no failure of the fitting.

12 HEAT CYCLE TEST

The test current shall be that power frequency current which raises the surface temperature of the conductor 100-degC above 40°C ambient temperature and maintains the temperature at a steady value. The minimum length of conductor used for determining this current shall be 2 meters and the conductor temperature shall be measured near the centre of the test length.

The joint shall be assembled in accordance with the manufacturer's recommendations on conductor of the size and type with which it is to be used. The assembly, to which a tensile load not exceeding 20% of the rated minimum failing load as specified in Table-II and Table-III may be applied, shall be directed indoors so that the conductor is roughly horizontal. Air shall be able to circulate freely round the assembly which shall not however, be exposed to draughts. The minimum length of conductor on each side of the fitting shall be 2 meters.

The test current shall be passed continuously through the assembly for a period of 30 min. The current shall then be interrupted, and the assembly shall be allowed to cool to within 5 degC. above the ambient temperature. The sequence of operation shall be repeated so that 100 cycles of heating and cooling are applied.

During the last five cycles, the maximum temperature, measured when the test current is flowing, at any points on the surface of the fittings, shall not exceed that of the conductor. At the end of the test the joint shall meet the requirements of the resistance test specified above. There shall be no sign of local heating, burning or fusing of any part of the joint or of the conductor.

13 RESISTANCE TEST

Test piece shall be assembled in accordance with the manufacturer's recommendations on the conductors of the size and type with which it is to be used. The electrical resistance shall be measured between points on the conductor on either side and just clear of the fitting and shall not exceed 75% of the measured resistance of the equivalent length of conductor.

The test may be made with direct current or with alternating current at any convenient power frequency. The current connections shall be at a distance not less than 50 times the diameter of the conductor from the fitting and shall be so made that effective contact is made with all these strands of the conductor which would be taken into account in calculating its equivalent resistance.

14 CORONA TEST

Typical insulator sets completely assembled with all fittings shall be set up in manner as nearly as possible to the arrangement to be used. A test voltage of 160kV, 100kV, and 50kV shall be applied for the nominal voltage of 220kV, 132kV and 66kV respectively between the conductor and earth for five minutes during which no corona formation shall be visible or audible with the room in complete darkness.

15 GALVANISING TEST

This test shall be carried out on all ferrous parts complying with the following requirements.

i) Weight of zinc coating

ii) Uniformity of zinc coating

iii) Adherence of zinc coating

This test shall be performed in accordance Specification P-82 (latest revision).

16 SAMPLING PLAN-ACCEPTANCE AND REJECTION

i) Sampling sizes are designated by code letters. Table-IV shall be used to find the applicable code letter for the particular lot or batch size for various units specified in this specification. While the number of units of product from each lot or, batch which are to be inspected (sample size) and the criteria for determining the acceptability of the lot or batch (acceptance and rejection numbers) for different code letters can be obtained from the table-IV given below.

ii) The number of sample units inspected shall be equal to the first sample size given in Table-V. If the number of defective units found in the first sample is equal to or less than the first acceptance number, the lot shall be accepted. If the number of defectives found in the first sample is equal to or greater than the first rejection number, the lot shall be rejected. If the number of defectives found in the first sample is between the first acceptance and rejection number, second sample of the size given by the plan shall be inspected. The No. of defectives found in the first and the second samples shall be accumulated. If the cumulative No. of defectives is equal to or less than the second acceptance number the lot shall be accepted. If the cumulative No. of defectives is equal to or greater than the second rejection number, the lot shall be rejected.

TABLE - IV SAMPLE SIZE

Lot or Batch Size	Sample size of test specified in Clause 10,11,13 & 15	Sample size for dimensional and finish defects
2 to 8	A	A
9 to 15	A	B
16 to 25	A	C
26 to 50	A	D
51 to 90	B	E
91 to 150	B	F
151 to 280	B	G
281 to 500	B	H
501 to 1200	C	J

TABLE-V SAMPLE ACCEPTANCE CRITERIA

Sample size code letters	Sample	Sample size	Cumulative sample size	Acceptance Number	Rejection Number
A	First	1	1	0	1
	Second	-	-	-	-
B	First	2	2	0	2
	Second	2	4	1	2
C	First	3	3	0	2
	Second	3	6	1	2
D	First	5	5	0	2
	Second	5	10	1	2
E	First	8	8	0	2
	Second	8	16	1	2
F	First	13	13	0	3
	Second	13	26	3	4
G	First	20	20	1	4
	Second	20	40	4	5
H	First	32	32	2	5
	Second	32	64	6	7
J	First	50	50	3	7
	Second	50	100	8	9

17 **MARKING AND PACKING**

The material shall be packed in wooden crates for export shipment to permit convenient handling and to protect against loss permit damage to final destination. Containers (Wooden Crates) shall be designed for handling by fork lift, truck and by slings around the container. The weight of each package should be between 100 and 150 Kg.

Packages shall be designed for rough handling. All wooden crates shall be clearly marked to indicate.

1. Quantity
2. Name of hardware item
3. Manufacturer's Name

All packages shall be numbered consecutively so that total shipment can be readily determined.

18 **INFORMATION TO BE SUPPLIED**

The following information shall be supplied with the bid and failure to supply the same may subject the bid to disqualification.

i) Detailed fully dimensioned drawings of hardware for Tension Strings.

ii) Specification giving material grade and composition of all items of hardware.

iii) Catalogues/literature of standardised items.

iv) Test certificates.

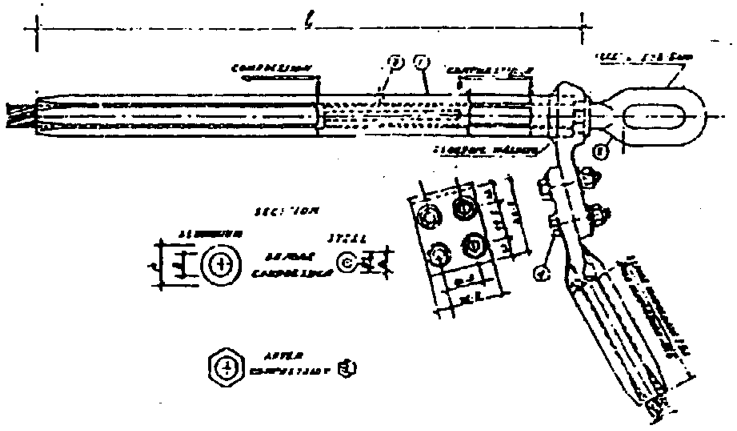
v) One complete sample of hardware for all types of Tension Strings.

vi) Detail of manufacturing & testing facilities available with manufacturers.

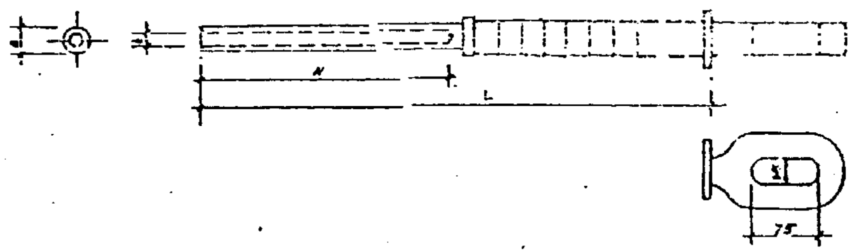
19 **DRAWINGS**

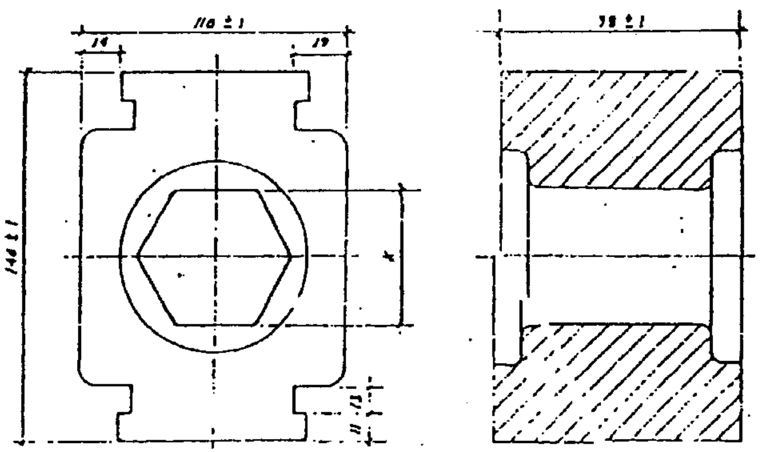
The following drawings from the part of this specification.

a) Tension clamp for ACSR Conductor (compression type) — PDW/DF-301
b) Self locking ball hook — PDW/DF-315
c) Socket eye — PDW/DF-332
d) Arcing horn — PDW/DF-317
e) Tension clamp for ACSR Conductor (Bolted type) — PDW/DF-328
f) Tension clamp for All Aluminium Conductor (compression type) — PDW/DF-329
g) Shackle Type 2 — PDW/DF-380
h) Single Tension String — PDW/DF-327
i) Yoke Plate — PDW/DF-377
j) Eye Clevis — PDW/DF-379
k) Socket Clevis Type A — PDW/DF-376
l) Ball Clevis — PDW/DF-382
m) Socket Clevis Type B — PDW/DF-378



STEEL COMPRESSION DEAD END





(DIES FOR COMPRESSION JOINTS)

DESCRIPTION	CUCKOO mm	RAIL mm	CARDINAL mm
CONDUCTOR DIA			
DIA OF COMPLETE COND.	27.7	29.6	30.4
DIA OF STEEL CORE	9.2	7.4	10.14
AL: JOINT			
OUTSIDE DIA (A)	45.5	50.5	54.0
INSIDE DIA (B)	28.0	31.0	33.5
LENGTH (ℓ)	580	625	600
STEEL JOINT			
OUTSIDE DIA (a)	20.5	19.0	24.0
INSIDE DIA (b)	9.75	8.0	10.75
LENGTH (L)	230	230	250
(N)	115	115	150
COMPRESSOR DIES			
FOR AL. (X)	39.5	44.0	48.0
FOR STEEL (X)	17.0	16.0	17.0

1	COMPRESSION DEAD END	1
2	COMPRESSION EYE END	1
3	PLUG FOR FILLER COMPOUND	2
4	5/8 DIA MACHINED BOLT	4

1		DIMENSION FOR ACSR CARDINAL CONDUCT ADDED	
NO	DATE	REVISIONS	BY

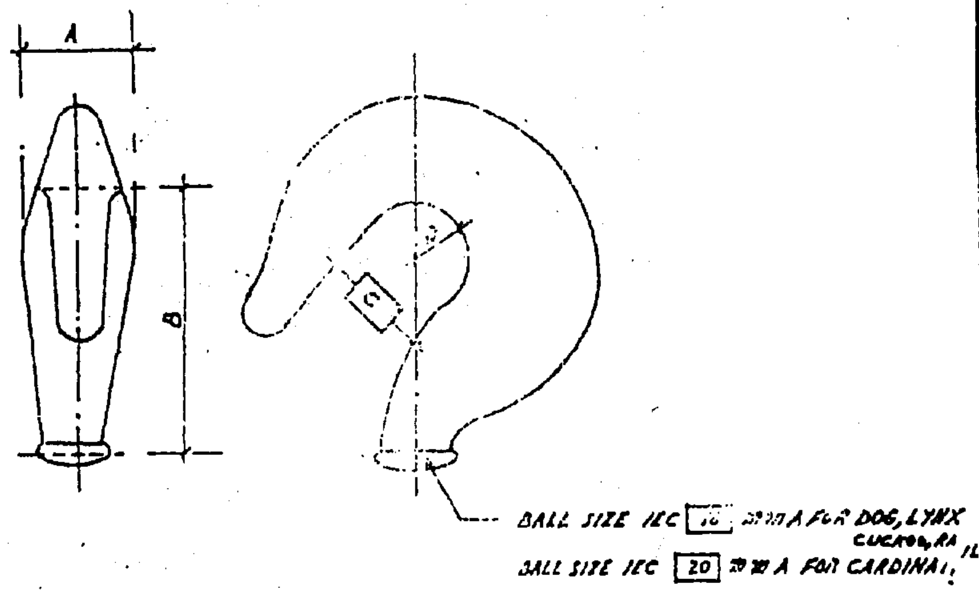
PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY — DESIGN DEPARTMENT

DRAWN	AZHAR SHAH	
CHECKED	GHULAM RASUL	
JUNIOR ENGINEER	MAZAR ABBAS	
SENIOR ENGINEER	MUHAMMAD -A- MALIK	
DIRECTOR	S. ISHTIAQ HUSSAIN	
CHIEF ENGINEER	JAVID AKHTAR	

TENSION CLAMP FOR ACSR CONDUCTORS (COMPRESSION TYPE)

SCALE : — DATE 5-2-1980

DWG. NO. PDIY/DF-301



DESCRIPTION	A	B	C	D
SELF LOCKING BALL HOOK	30	60	22	14

☐ INDICATES BINDING DIMENSION

DIMENSIONS SHOWN IN MILLIMETRES

1	2-9-82	BALL SIZE FOR ACSR CARDINAL CONDUCTOR ADDED	
NO	DATE	REVISIONS	BY

PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY

DESIGN DEPARTMENT

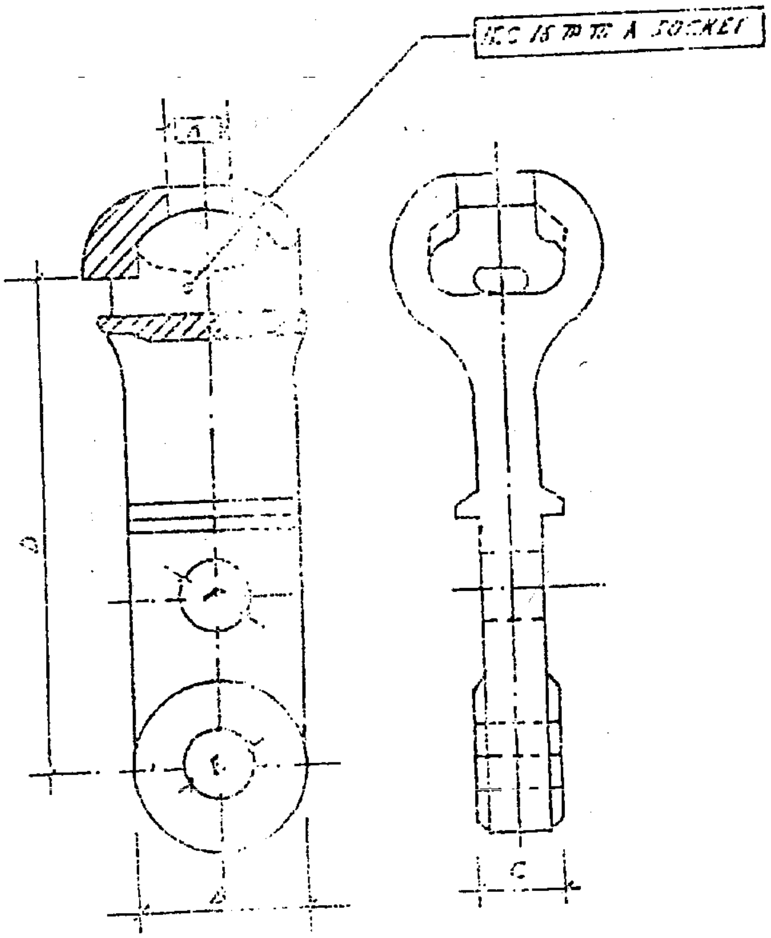
DRAWN	[illegible] SHAH	
CHECKED	[illegible] RASUL	
JUNIOR ENGINEER	[illegible] ABBAS	
SENIOR ENGINEER	[illegible] -A- MALIK	
DIRECTOR	[illegible] HUSSAIN	
CHIEF ENGINEER	[illegible] AKHTER	

SELF LOCKING BALL HOOK

SCALE

DATE 27-9-80

DWG: NO. PDW/DF315



SOCKET EYE

[illegible]	B	C	D	E	F
[illegible]	91.5	22	11[illegible]	[illegible]	14

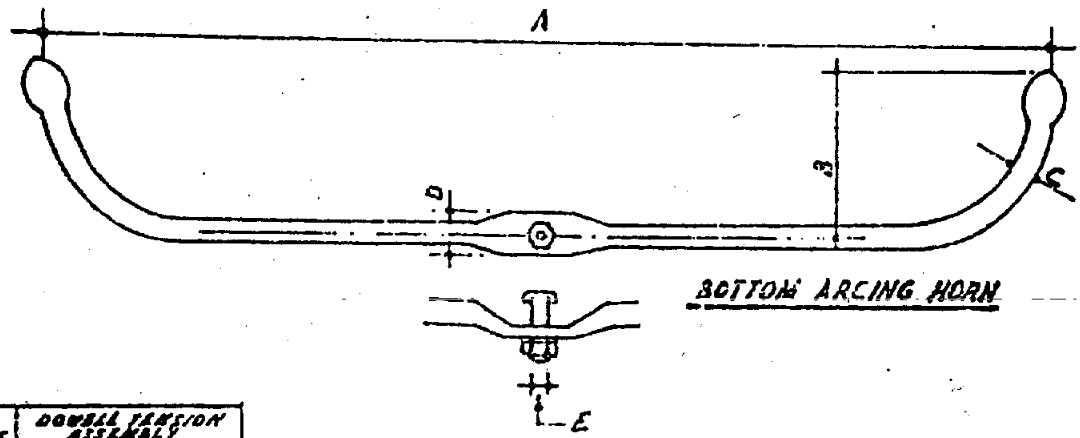
▭ INDICATES BINDING DIMENSION

DIMENSION SHOWN IN MILLIMETRES

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY			DESIGN DEPARTMENT
DRAWN	AKBAR SHAH		SOCKET EYE (FOR TENSION STRING)
CHECKED	GHULAM RASUL		
DESIGN ENGINEER	[illegible] ABBAS		
SENIOR ENGINEER	MUNAWAR. A MALIK		
DIRECTOR	[illegible] IFTIKHAR HUSSAIN		SCALE — / DATE 26-10-19[illegible]
CHIEF ENGINEER	JAVID AKHTER		DWG. NO. PDW/DF-332

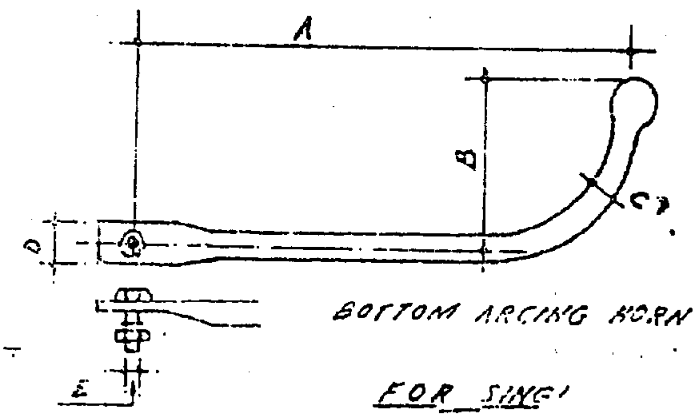
FOR SINGLE SUSPENSION ASSEMBLY

VOLTAGE KV	SINGLE SUSPENSION ASSEMBLY					SINGLE TENSION/DOUBLE SUSPENSION ASSEMBLY				
	A	B	C	D	E	A	B	C	D	E
66	500	110	14	30	12	250	110	14	30	12
132	600	120	14	30	12	300	120	14	30	12
220	750	125	18	30	12	375	125	18	30	12



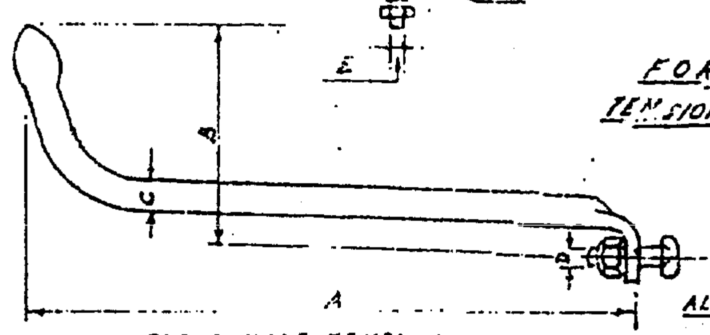
BOTTOM ARCING HORN

VOLTAGE	DOUBLE TENSION ASSEMBLY			
	A	B	C	D
66 KV	245	115	14	12
132 KV	295	125	16	12
220 KV	370	140	18	12



BOTTOM ARCING HORN

FOR SING' TENSION ASSEM.

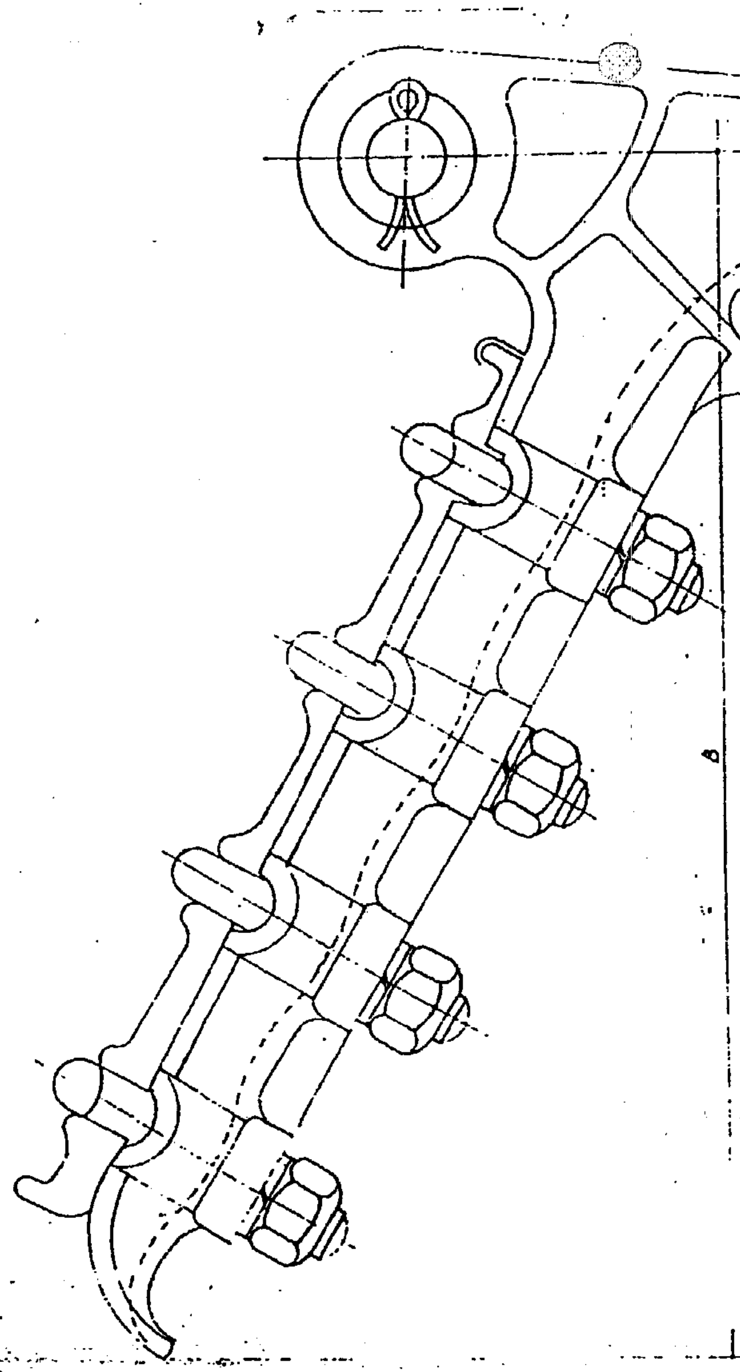


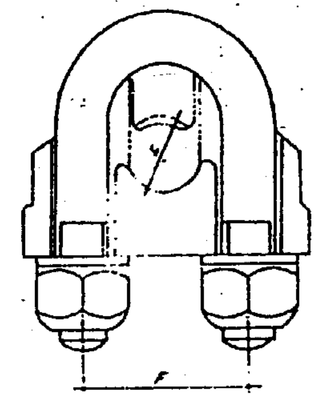
ALL DIMENSION IN MILLIMETRES

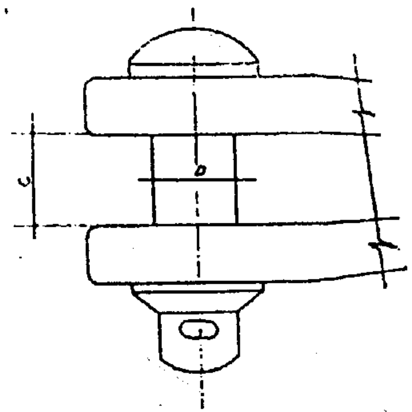
FOR DOUBLE TENSION ASSEMBLY
BOTTOM ARCING HORN

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY			DESIGN DEPARTMENT
DRAWN	AZHAR SHAH		ARCING HORNS
CHECKED	GHULAM RASUL		
JUNIOR ENGINEER	NAZAR ABBAS		
SENIOR ENGINEER	MUHAMMAR-A-MALIK		
DIRECTOR	S. ISHTIAQ HUSSAIN		SCALE / DATE 27-9.80
CHIEF ENGINEER	JAVID AKHTER		DWG: NO. PDW/DF-317

NO	DATE	REVISIONS	BY
1	5-9-82	BOTTOM ARCING HORN DOUBLE TENSION ASSEMBLY ADDED	







SECTION Y-Y

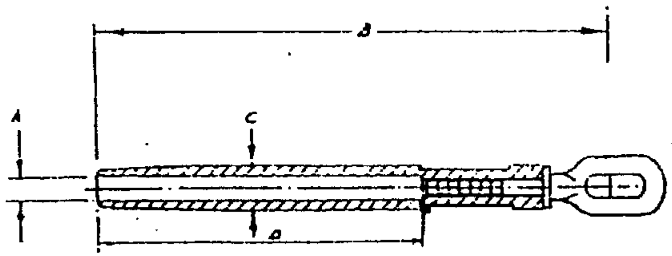
DESCRIPTION	DIMENSIONS					
	A	B	C	D	E	F
DOG	180	312	24	16	14.2	35
LYNX	200	318	24	16	19.5	35

☐ INDICATES BINDING DIMENSION

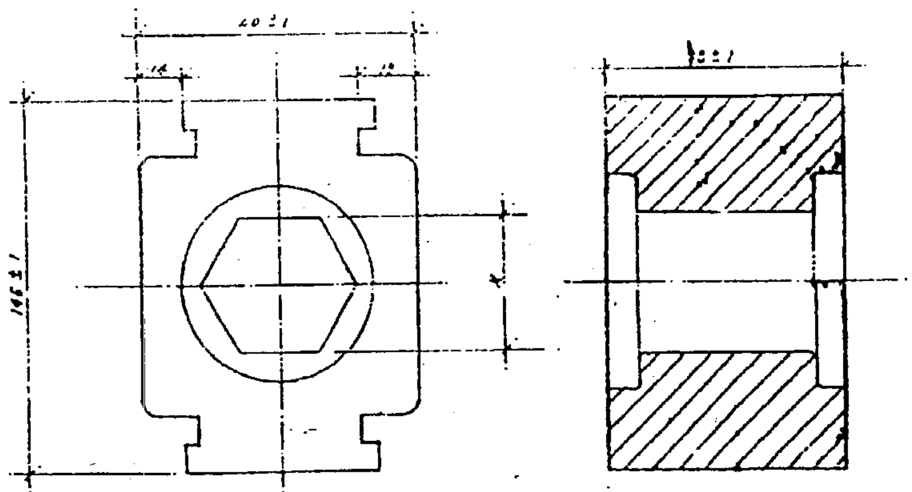
DIMENSION SHOWN IN MILLIMETRES

NO	DATE	REVISIONS	BY

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY			DESIGN DEPARTMENT
DRAWN	AZHAR SHAH		TENSION CLAMP FOR ACSR CONDUCTORS (BOLTED TYPE)
CHECKED	GHULAM RASUL		
JUNIOR ENGINEER	NAZAR ABBAS		
SENIOR ENGINEER	MUHAMAD-A-MALIK		
DIRECTOR	S. ISHTIAQ HUSSAIN		SCALE ✓ DATE 7-10-1980
CHIEF ENGINEER	JAVID AKHTAR		DWG. NO. PDW/DF-328



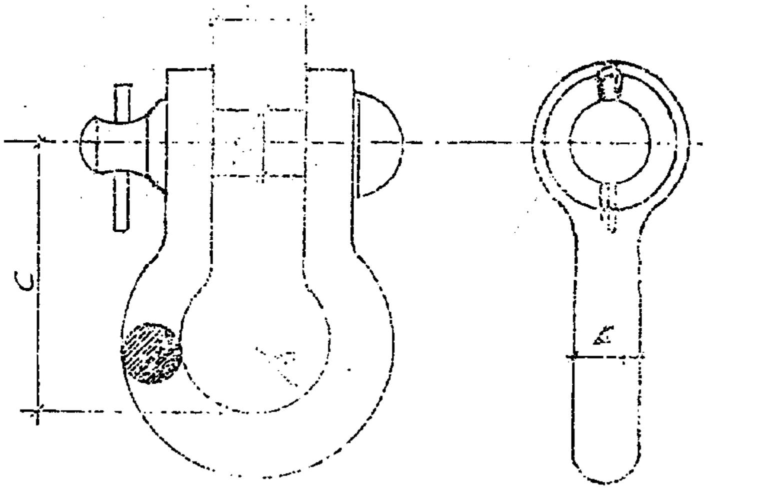
CONDUCTOR DESIGNATION	DIA METER	AREA mm²	DIMENSION (mm)				
			A	B	C	D	K
ARBUTUS	26.1	400	18.6	572	47.8	356.0	40.8
HAWTHORN	31.9	600	34.1	570	54.0	360.0	46.0



(DIES FOR COMPRESSION JOINTS)

NO	DATE	REVISIONS	BY

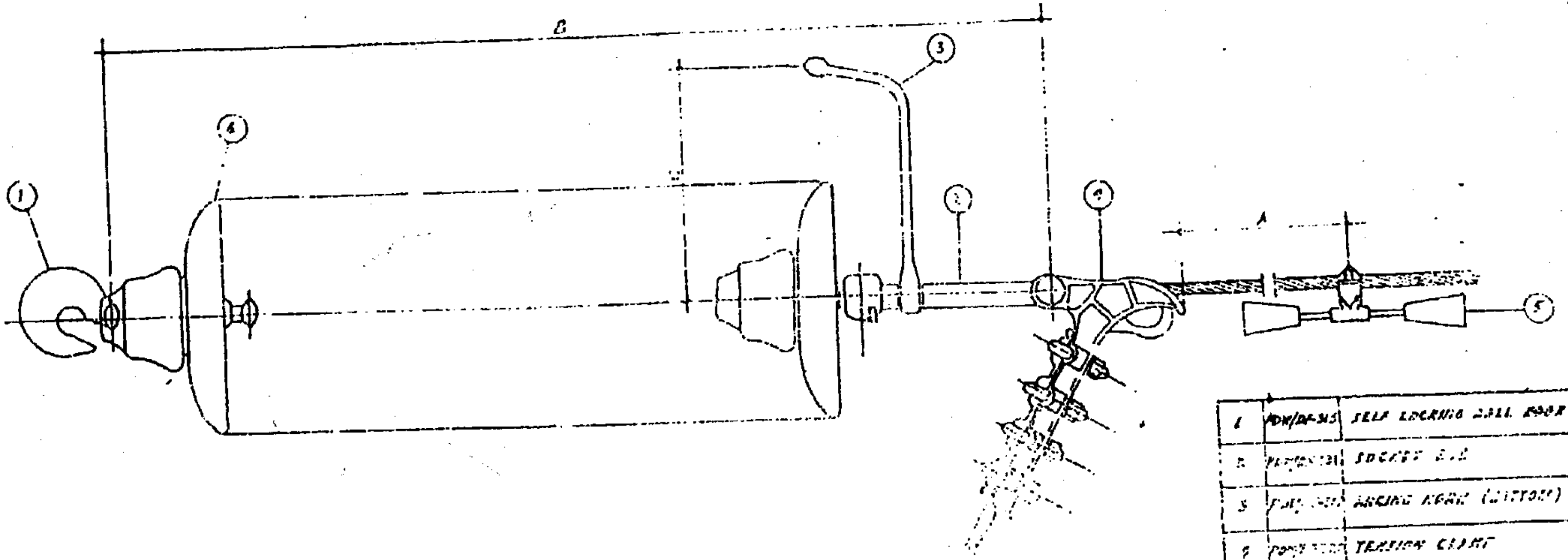
PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY			DESIGN DEPARTMENT
DRAWN	AZHAR SHAH		TENSION CLAMP FOR ALUMINIUM CONDUCTORS (COMPRESSION TYPE)
CHECKED	GHULAM RASUL		
JUNIOR ENGINEER	NAZAR ABBAS		
SENIOR ENGINEER	MUNAWAR-A-MALIK		
DIRECTOR	S. ISHTIAQ HUSSAIN		SCALE ✓ DATE 7-10-1980
	JAVID AKHTAR		DWG. NO PDM/DF-329



DESCRIPTION	DIMENSIONS				
	A	B	C	D	E
SHACKLE	[illegible]	22	100	20	[illegible]

DIMENSION SHOWN IN MILLIMETRES

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY			DESIGN DEPARTMENT
DRAWN	AKYAR SHAH		SHACKLE TYPE – 2
CHECKED	GHULAM RASUL		
ASSTT. DIRECTOR	NIZAR ABBAS		
DEPUTY DIRECTOR	MUKHTAR-A-MALIK		
DIRECTOR	S. ISHTIAQ HUSSAIN		SCALE — DATE 15-9-82
CHIEF ENGINEER			DWG. NO. PDW/DF-300



1	PDW/DF-315	SELF LOCKING BALL HOOK
2	[illegible]	SOCKET [illegible]
3	[illegible]	ARCING HORN (BOTTOM)
4	[illegible]	TENSION CLAMP
5	PDW/DF-[illegible]	VIBRATION DAMPERS (STOCKBRIDGE)
6		DISC INSULATORS

CONDUCTOR DESIGNATION	DIMENSIONS A	B	C 220KV	132KV	[illegible]
RAIL	1515	—	375	300	--
CUCKOO	1450	—	—	300	--
LYNX	1140	1735	—	300	--
DOG	610	508	—	--	[illegible]

[ ] INDICATES ARCING DIMENSION

DIMENSION SHOWN IN MILLIMETRES

NO	DATE	REVISIONS	BY

PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY

DESIGN DEPARTMENT

DRAWN	AKBAR SHAH	
CHECKED	GHULAM RASUL	
JUNIOR ENGINEER	AKTAR ABBAS	
SENIOR ENGINEER	MUHAMMAD-A-MALIK	
DIRECTOR	S. IMTIAZ HUSSAIN	
CHIEF ENGINEER	JAVID AKHTAR	

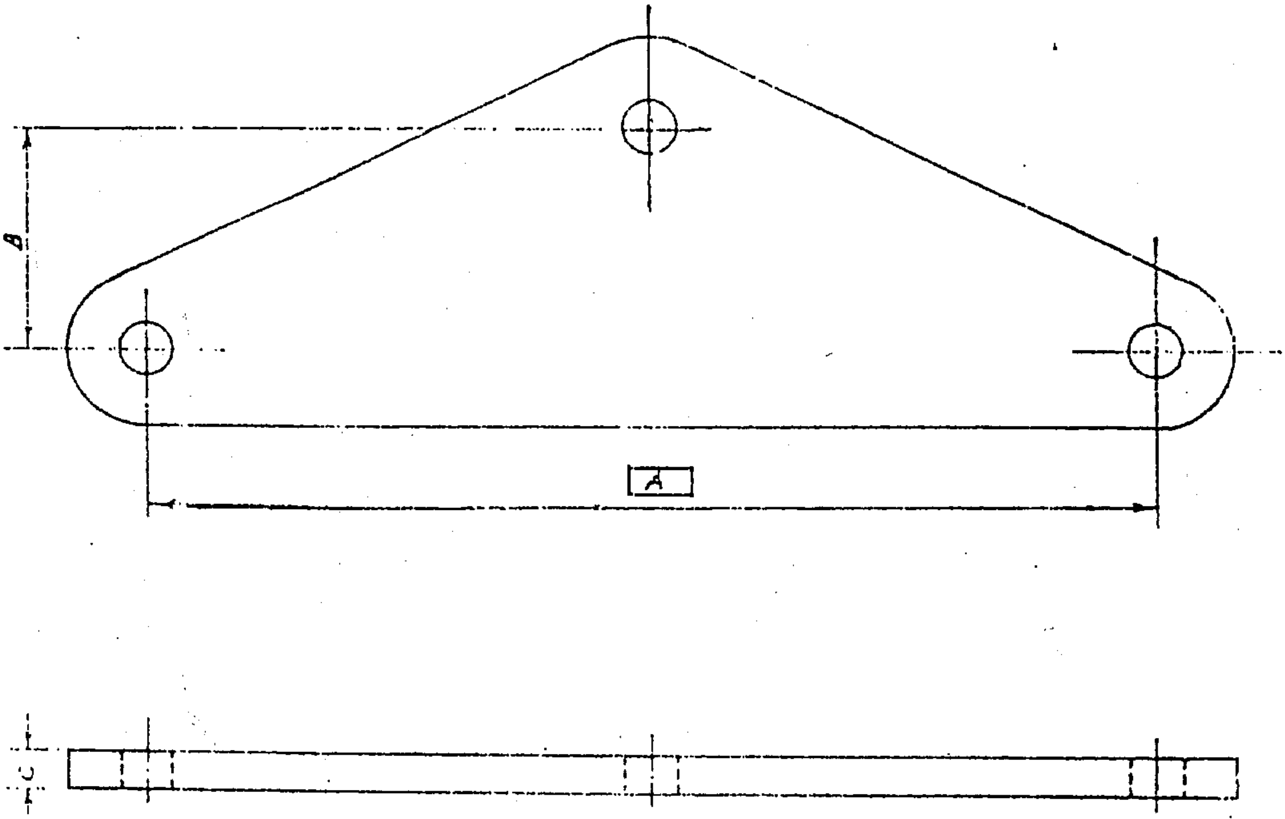
SINGLE TENSION STRING

SCALE -

DATE 7-[illegible]

DWG: NO. PDW/DF-[illegible]

PSWL/385: 527

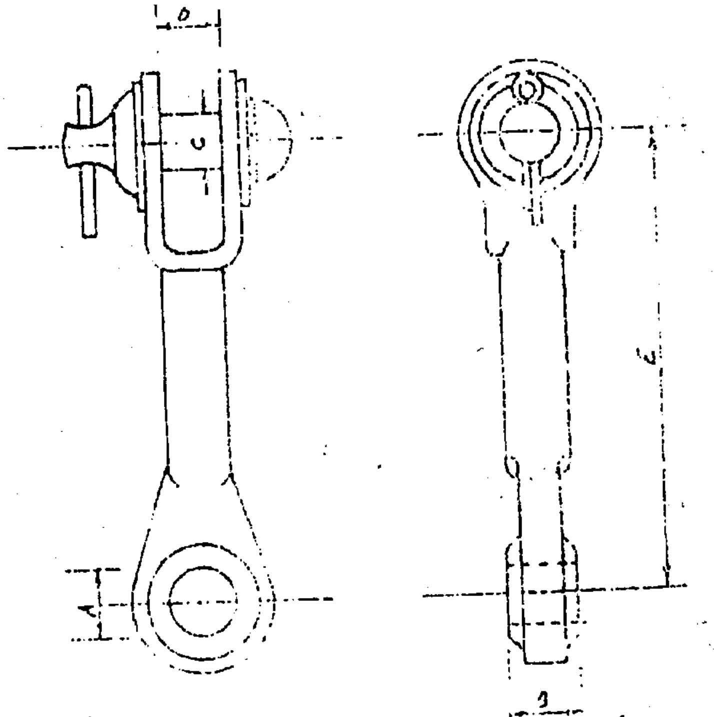


DESCRIPTION	A	B	C
DOG, LYNX	400	90	16
CUCKOO, RAIL CARDINAL	400	90	18

ALL DIMENSIONS IN MILLIMETRES

☐ INDICATES BINDING DIMENSIONS

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY			DESIGN DEPARTMENT POWER
DRAWN	AZHAR SHAH		YOKE PLATE
CHECKED	GHULAM RASUL		
ASSTT DIRECTOR	NAZAR ABBAS		
DEPUTY DIRECTOR	MUNAWAR-A-MALIK		
DIRECTOR	S. ISHTIAQ HUSSAIN		SCALE ✓ DATE. 13-9-92.
CHIEF ENGINEER			DWG: NO. PDW/DF-377

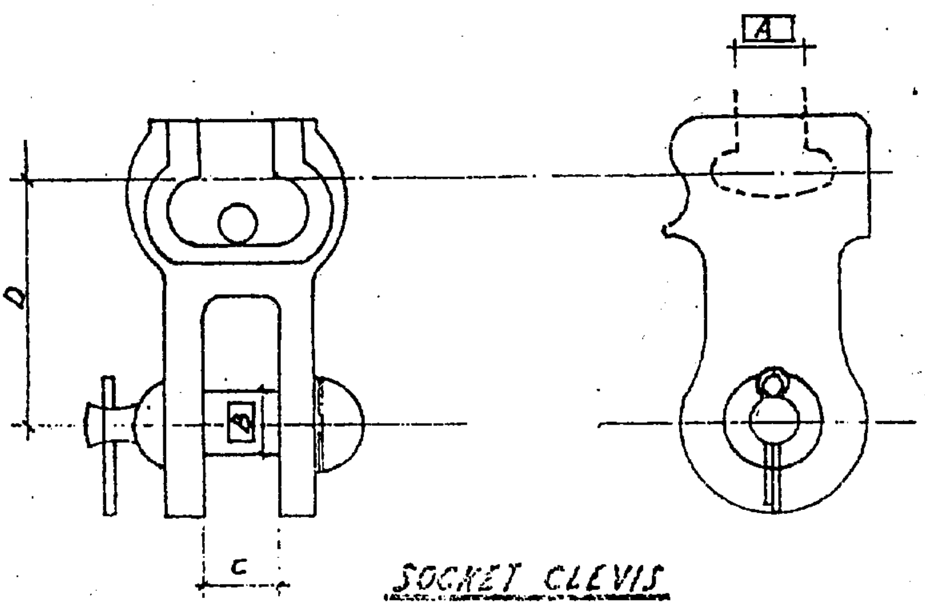


EYE CLEVIS

DESCRIPTION	A	B	C	D	E
DOG, LYNX	16	22	16	10	60
CUCKOO, RAIL CARDINAL	18	55	16	20	50

ALL DIMENSION IN MILLIMETRES

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY			DESIGN DEPARTMENT POWER
DRAWN	AMJAD ALI SHAH		EYE CLEVIS WITH 90° EYE
CHECKED	GHULAM RASUL		
JUNIOR DIRECTOR	NAZAR ABBAS		
DEPUTY DIRECTOR	MUNAWAR-A-MALLK		
DIRECTOR	S. ISHTIAQ HUSSAIN		SCALE ✓ — DATE 13-9
CHIEF ENGINEER			DWG: NO. PDW/DF-3



SOCKET CLEVIS
TYPE - A

DESCRIPTION	DIMENSIONS			
	A	B	C	D
DOG, LYNX	15	15	18	70
CUCKOO, RAIL	16	16	20	70
CARDINAL	20	16	20	70

DIMENSIONS SHOWN IN MILLIMETRES

☐ INDICATES BINDING DIMENSIONS

PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY

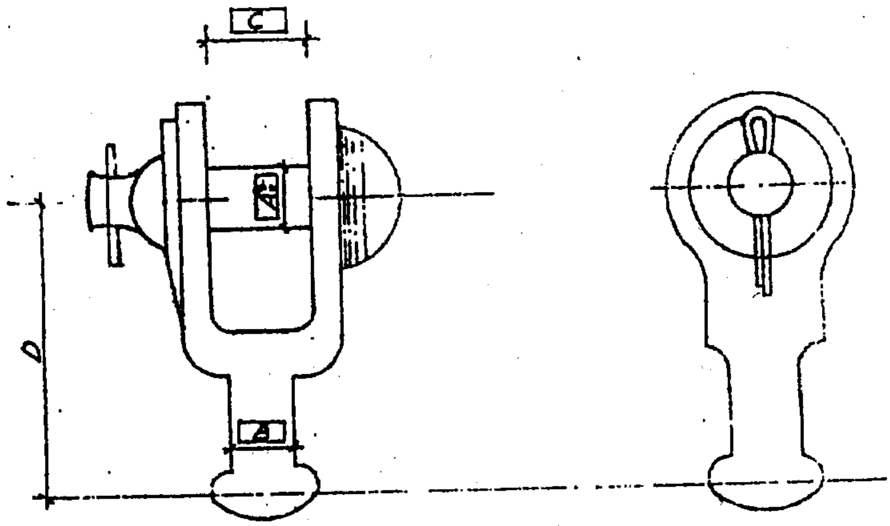
DESIGN DEPARTMENT

DRAWN	AZHAR SHAH	
CHECKED	GHULAM RASUL	
ASSTT. DIRECTOR	NAZAR ABBAS	
DEPUTY DIRECTOR	MUNAWAR-A-MALIK	
DIRECTOR	S. ISHTIAQ HUSSAIN	
CHIEF ENGINEER		

SOCKET CLEVIS
TYPE - A

SCALE ✓ DATE 13-9-82

DWG. NO. PDW/DF-376



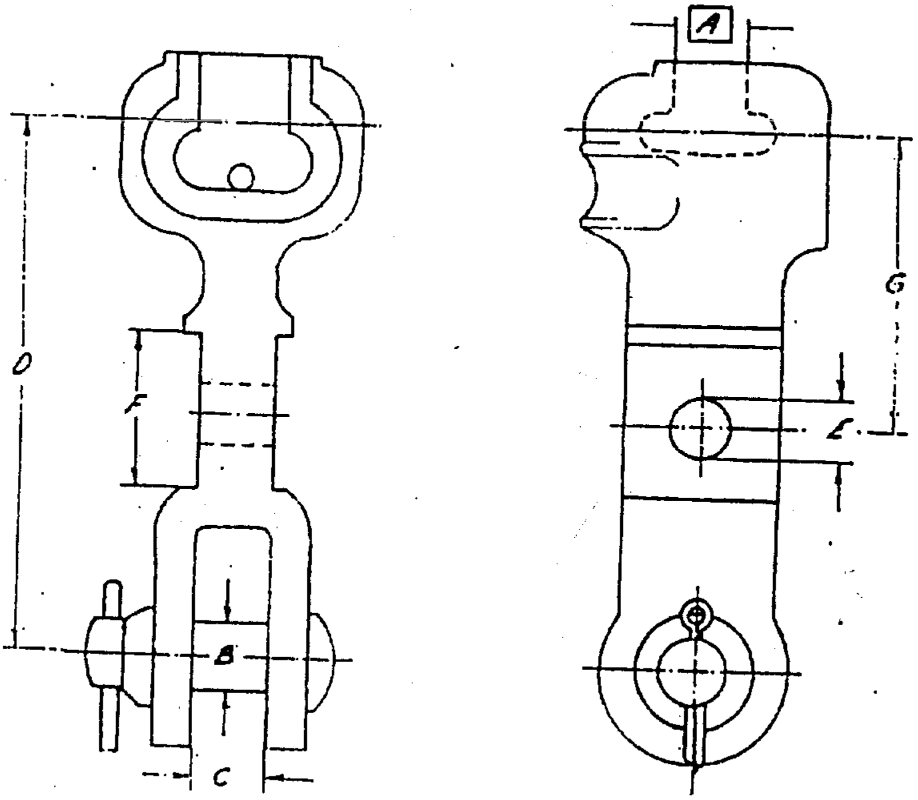
BALL CLEVIS

DESCRIPTION	DIMENSIONS			
	A	B	C	D
DOG, LYNX	16	16	16	75
CUCKOO, RAIL	16	16	20	75
CARDINAL	16	20	20	75

DIMENSION SHOWN IN MILLIMETRES

☐ INDICATES BINDING DIMENSIONS

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY			DESIGN DEPARTMENT
DRAWN	AZHAR SHAH		BALL CLEVIS
CHECKED	GHULAM RASUL		
ASSTT. DIRECTOR	NAZAR ABBAS		
DEPUTY DIRECTOR	MUNAWAR-A-MALIK		
DIRECTOR	S. ISHTIAQ HUSSAIN		SCALE ✓ DATE 13-9-82
CHIEF ENGINEER			DWG. NO. PDW/DF-382



SOCKET CLEVIS

TYPE - B

DESCRIPTION	A	B	C	D	E	F	G
DOG, LYNX	15	16	18	110	14	30	60
CUCKOO, RAIL	16	16	20	110	14	30	60
CARDINAL	20	16	20	110	14	30	60

☐ INDICATES BINDING DIMENSIONS

DIMENSION SHOWN IN MILLIMETERS.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY			DESIGN DEPARTMENT (POWER)
DRAWN	IJAZ MAHMOOD		SOCKET CLEVIS TYPE - B
CHECKED	A. LATIF		
JUNIOR ENGINEER	NAZAR ABBAS		
SENIOR ENGINEER	MUNAWAR A. MALIK		
DIRECTOR	S. ISHTIAQ HUSSAIN		SCALE:- / DATE:- 13-9-82
CHIEF ENGINEER			DWG. NO. PDM/DF- 378

SPECIFICATION P-144: 80

MID SPAN JOINTS AND REPAIR SLEEVES FOR TRANSMISSION LINES

PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY
DESIGN DEPARTMENT (T&G) POWER

SPECIFICATION P-144: 80

MIDSPAN JOINTS AND REPAIR SLEEVES FOR TRANSMISSION LINES

AMENDMENT NO. 1 DATED DEC. 1982.

1. Replace Table-I of subclause 2.1 with the following:

	Description	Desig-nation	Cond. OD (mm)
a)	Mid span joint for DOG	MS-D	14.2
b)	Mid span joint for LYNX	MS-L	19.5
c)	Mid span joint for CUCKOO	MS-C	27.7
d)	Mid span joint for RAIL	MS-R	29.6
e)	Mid span joint for CARDINAL	MS-CA	30.4
f)	Repair sleeves for DOG	RS-D	14.2
g)	Repair sleeves for LYND	RS-L	19.5
h)	Repair sleeves for CUCKOO	RS-C	27.7
i)	Repair sleeves for RAIL	RS-R	29.6
j)	Repair sleeves for CARDINAL	RS-CA	30.4

2. The sub para (ii) of subclause 2.1 is substituted as follows:

ii) The next letter stands for the name of conductor for which the hardware is meant for i.e. 'D' for DOG, 'L' for LYNX, 'C' for CUCKOO, 'R' for RAIL and 'CA' for CARDINAL.

3. Replace Table-II of sub clause 3.1 with the following:

TABLE - II

Rating of Hardware

Sr. No.	Description	Failing load in Kg.
1.	MS-D	3300
2.	MS-L	8000
3.	MS-C	12000
4.	MS-R	12000
5.	MS-CA	16000
6.	RS-L	-
7.	RS-L	-
8.	RS-C	-
9.	RS-R	-
10.	RS-CA	-

4. The first sentence of sub para 1 of clause 11 is substituted as follows:

   " The test current shall be that power frequency current which raises the surface temperature of the conductor 100 degC above 40°C ambient temperature and maintains the temperature at a steady value".

5. The last sentence of sub para 3 of clause 11 is substituted as follows:

   " The sequence of operation shall be repeated so that 100 cycles of heating and cooling are applied".

6. The principal dimensions of Mid Span Joints and Repair Sleeves for ACSR CARDINAL Conductor are added on Dwg. No.PDW/DF-302.

CONTENTS

PRINTING HISTORY

First approved on 21st September, 1980.

AMENDMENT NO.1 DEC.1982

SPECIFICATION P-144: 80

MID SPAN JOINTS AND REPAIR SLEEVES FOR TRANSMISSION LINES

0 FOREWORD

0.1 This standard has been introduced by WAPDA and has been prepared by the Transmission Line Section of the office of the Chief Engineer (Designs).

0.2 This standard is intended only for the purpose of technical specification to facilitate procurement of materials and does not include provision of contract.

0.3 This specification is subject to periodic revision as and when required.

1 SCOPE

1.1 This specification covers the mid span joints and repair sleeves for ACSR Conductor intended to be used on Transmission Lines.

2 TYPES OF MID SPAN JOINTS AND REPAIR SLEEVES

2.1 The hardware described in this Specification are of the following types:

TABLE - 1

Description	Designation	Cond.OD(mm)
a) Mid span joint for DOG	MS - D	14.2
b) Mid span joint for LYNX	MS - L	19.5
c) Mid span joint for CUCKOO	MS - C	27.7
d) Mid span joint for RAIL	MS - R	29.6
e) Repair sleeves for DOG	RS - D	14.2
f) Repair sleeves for LYNX	RS - L	19.5
g) Repair sleeves for CUCKOO	RS - C	27.7
h) Repair sleeves for RAIL	RS - R	29.6

The hardware described above in this Specification has been designated by the code numbers. These codes have been assigned in the following manner.

i) The first two letters stand for Mid Span joints or repair sleeves i.e. MS for mid span joint and RS for repair sleeves.

ii) The next letter stands for the name of conductor for which the hardware is meant for i.e. 'D' for DOG, 'L' for LYNX, 'C' for CUCKOO and 'R' for RAIL.

3 RATING OF HARDWARE

3.1 The hardware shall be of the rating as specified in Table-II below:

TABLE - II

Rating of Hardware

Sr. No.	Description	Failing load in Kg
1.	MS-D	3300
2.	MS-L	8000
3.	MS-C	12000
4.	MS-R	12000
5.	RS-D	-
6.	RS-L	-
7.	RS-C	-
8.	RS-R	-

4 GENERAL REQUIREMENTS

4.1 Generally each mid span joint shall consist of:

1 Steel sleeve galvanised

1 Aluminium sleeve

4.2 The repair sleeve shall be made of 2 pieces. It shall be compression type and shall made of all aluminium.

4.3 All ferrous parts shall be hot dip galvanised in accordance with WAPDA Specification P-82.(latest revision)

5 DIMENSIONS AND TOLERANCES

5.1 All hardware shall generally be in accordance with drawings forming a part of this specification.

5.2 The dimensions of these parts of hardware that mate with other hardware or that determine the length of insulator string are binding and are shown enclosed on the drawing.

5.3 For dimensions that are fixed and binding the tolerance will be plus or minus 2 percent with a maximum of 0.8mm. For dimensions that are shown as MAX or MIN there shall be no plus and minus tolerance respectively. The tolerance in the opposite sense may however be 4%.

6 DESIGN AND MATERIAL

6.1 Mid Span Joints

Mid span joints shall be of the compression type. They shall be such that after compression they shall assume a hexagonal cross-section. The electrical conductivity and current carrying capacity shall not be less than an equal length of conductor.

Conductor joints shall be made of aluminium with a galvanised steel inner sleeve. Mid span joints shall be made according to Dwg. No. PDW/DF-302.

6.2 Repair Sleeves

Repair sleeves shall be designed to make good a conductor of which not more than one-fifth of the strands in the outer layer have been served.

6.3 Repair sleeve shall be composed of two aluminium pieces fitted into each other and forming an integral part. They shall be compressed on the damaged part of conductor by the same dies used for aluminium component of dead-end and mid-span joint and shall have un-installed length as indicated in Dwg. No. PDW/DF-302.

7 TESTS

7.1 Type Tests

7.1.1 Type tests are intended to verify and establish design characteristics. They shall be made once only on hardware identical in all essential details with those to be supplied.

i) Mechanical Test)
ii) Heat Cycle Test) On mid span joints only
iii) Resistance Test)

7.1.2 The bidder shall supply heat cycle test result with the bid.

7.2 Sample Tests

Sample tests shall be made to verify the quality and workmanship. The number of samples shall be nearest whole number to one half of one percent of the batch offered for inspection.

The following sample test shall be performed in accordance with the clause:

i)	Visual examination	
ii)	Verification of dimensions	
iii)	Mechanical tests	On mid span joints
iv)	Resistance tests	On mid span joints
v)	Galvanising tests	On ferrous parts.

8 VISUAL EXAMINATION

The test samples shall be examined visually for the following defects.

Visual Examination

Examination	Defects
Material	Not as specified in relevant clauses.
Construction	Not of the shape given in relevant Drawing. Any part missing.
Finish	Galvanising not proper. Presence of burrs, black and bare spots, dross and projections, which will interfere with proper use of the articles.

9 VERIFICATION OF DIMENSIONS

The binding dimensions of the hardware shall be measured and shall be as shown on the relevant approved drawings subject to the tolerance given in clause 5.

10 MECHANICAL TEST

10.1 Test piece shall be assembled in accordance with manufacturer's recommendations on conductor of the size and type with which it is to be used. The assembly shall be mounted in a tensile testing machine and anchored in a manner approximating as nearly as possible to the arrangement to be used in service, precautions being taken to avoid birdcaging of the conductor. The length of conductor between the fitting under test and any other clamp or joint in the test assembly should preferably be not less than 100 times the overall diameter of the conductor.

10.2 A tensile load of about 50 percent of the failing load specified in Table-II shall be applied and the conductor shall be marked in such a way that movement relative to the fitting can easily be detected. Without any subsequent adjustment of the fitting, the load shall be steadily increased to 95% of the failing load and then reduced to 90% of the failing load and maintained for 1-minute. There shall be no movement of the conductor relative to the fitting due to slip during this 1-minute period and no failure of the fitting.

11 HEAT CYCLE TEST

The test current shall be 40^{o}C that power frequency current which raises the surface temperature of the conductor 40 degC above 40 degC ambient temperature and maintains the temperature at a steady value. The minimum length of conductor used for determining this current shall be 2 meters and the conductor temperature shall be measured near the centre of the test length.

The joint shall be assembled in accordance with the manufacturer's recommendations on conductor of the size and type with which it is to be used. (The assembly, to which a tensile load not exceeding 20% of the rated minimum failing load as specified in Table-II may be applied, shall be directed indoors so that the conductor is roughly horizontal). Air shall be able to circulate freely round line assembly which shall not however, be exposed to draughts. The minimum length of conductor on each side of the fitting shall be 2 meters.

The test current shall be passed continuously through the assembly for a period of 30 min. The current shall then be interrupted, and the assembly shall be allowed to cool to within 5 degC above the ambient temperature. The sequence of operation shall be repeated so that 250 cycles of heating and cooling are applied.

During the last five cycles, the maximum temperature measured when the test current is flowing at any points on the surface of the fittings, shall not exceed that of the conductor. At the end of the test the joint shall meet the requirements of the resistance test specified above. There shall be no sign of local heating, burning or fusing of any part of the joint or of the conductor.

12 RESISTANCE TEST

12.1 The fitting shall be assembled in accordance with the manufacturer's recommendations on conductors of the size and type with which it is to be used. The electrical resistance shall be measured between points on the conductor on either side and just clear of the fitting and shall not exceed 75% of the measured resistance of the equivalent length of conductor.

12.2 The test may be made with direct current or with alternating current at any convenient power frequency. The current connections shall be at a distance not less than 50 times the diameter of the conductor from the fitting and shall be so made that effective contact is made with all these strands of the conductor which would be taken into account in calculating its equivalent resistance.

13 GALVANISING TEST

This test shall be carried out on all ferrous parts complying with the following requirements.

i) Weight of zinc coating

ii) Uniformity of zinc coating

iii) Adherence of zinc coating

This test shall be performed in accordance with WAPDA Specification P-82.(latest revision)

14 SAMPLING PLAN - ACCEPTANCE AND REJECTION

i) Sampling sizes are designated by code letters. Table-III shall be used to find the applicable code letter for the particular lot or batch size for various tests specified in this Specification. While the number of units of product from each lot or batch which are to be inspected (sample size) and the criteria for determining the acceptability of the lot or batch (acceptance & rejection numbers) for different code letters can be obtained from the table-IV given below.

ii) The number of sample units inspected shall be equal to the first sample size given in Table-IV. If the number of defective units founding the first sample is equal to less than the first acceptance number, the lot shall be acceptable. If the number of defectives found in the first sample is equal to or greater than the first rejection number, the lot shall be rejected. If the number of defectives found in the first sample is between the first acceptance and rejection number, a second sample of the size given by the plan shall be inspected. The number of defectives found in the first and the second samples shall be accumulated. If the cumulative number of defectives is equal to or less than the second acceptance number, the lot shall be acceptable. If the cumulative number of defectives is equal to or greater than the second rejection number, the lot shall be rejected.

TABLE - III Sample Size

Lot of Batch Size	Sample size for Test specified in Clause 10,12 & 13	Sample size for dimensional and finish defects
2 to 8	A	A
9 to 15	A	B
16 to 25	A	C
26 to 50	A	D
51 to 90	B	E
91 to 150	B	F
151 to 280	B	G
281 to 500	B	H
501 to 1200	C	J

TABLE - IV

Sample acceptance criteria

Sample size code letters	Sample	Sample size	Cumulative sample size	Acceptance number	Rejection number
A	First	1	1	0	1
	Second	-	-	-	-
B	First	2	2	0	2
	Second	2	4	1	2
C	First	3	3	0	2
	Second	3	6	1	2
D	First	5	5	0	2
	Second	5	10	1	2
E	First	8	8	0	2
	Second	8	16	1	2

F	First	13	13	0	3
	Second	13	26	3	4
G	First	20	20	1	4
	Second	20	40	4	5
H	First	32	32	2	5
	Second	32	64	6	7
J	First	50	50	3	7
	Second	50	100	8	9

15 MARKING AND PACKING

The material shall be packed in wooden crates for export shipment to permit convenient handling and to protect against loss or damage to final destination. Containers (wooden crates) shall be designed for handling by fork-lift, truck and by slings around the container. The weight of each package should be between 100 and 150 kg.

Packages shall be designed for rough handling. All wooden crates shall be clearly marked to indicate.

1. Quantity
2. Name of hardware item
3. Manufacturer's Name

All packages shall be numbered consecutively so that total shipment can be readily determined.

16 INFORMATION TO BE SUPPLIED

The following information shall be supplied with the bid and failure to supply the same may subject the bid to disqualifications:

i) Detailed fully dimensioned drawings of midspan joints and repair sleeves

ii) Specification giving material grade & composition of all items of hardware

iii) Catalogues/literature of standardised items

iv) Test certificates

v) One complete sample of all types of midspan joints and repair sleeves

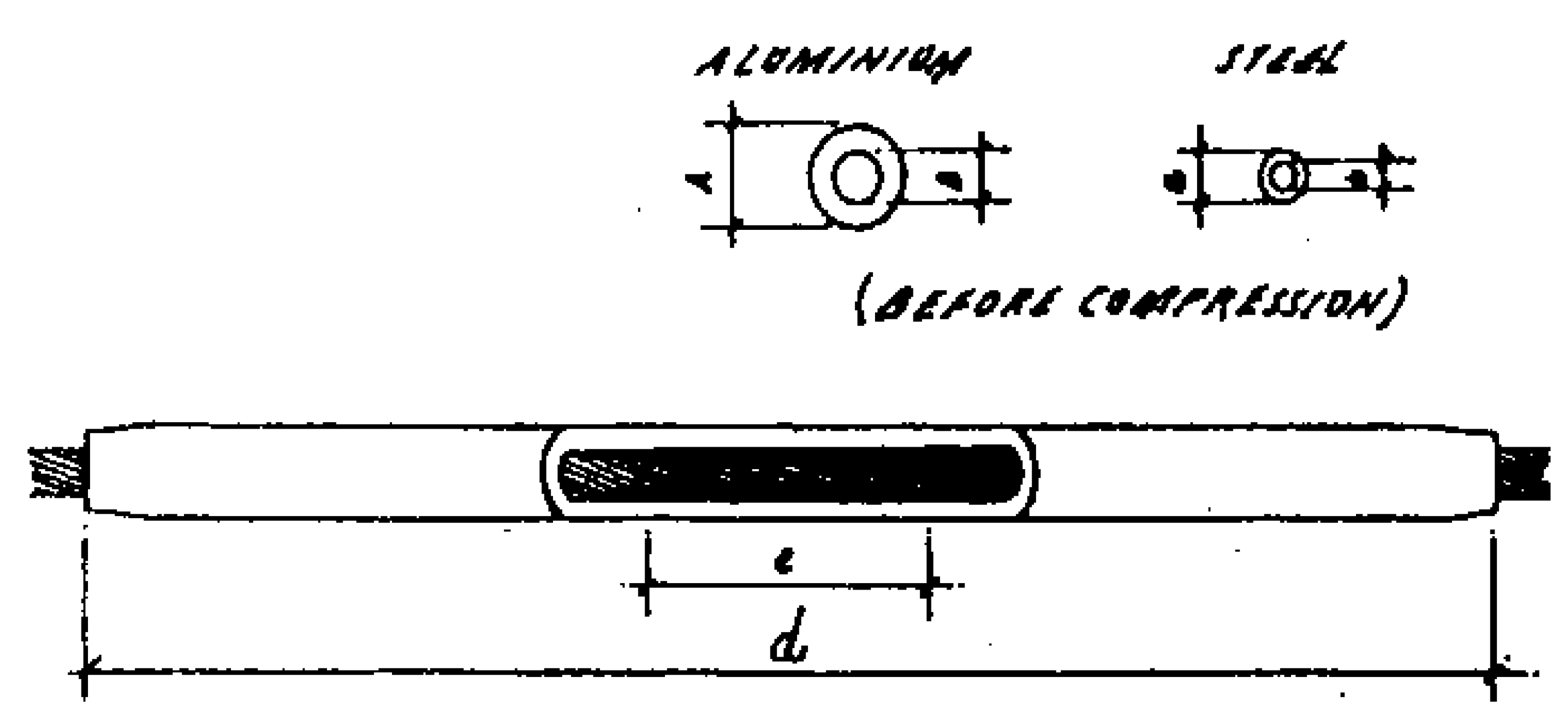
vi) Detail of manufacturing & testing facilities available with manufacturers.

17 DRAWING

The following drawing form the part of this specification:

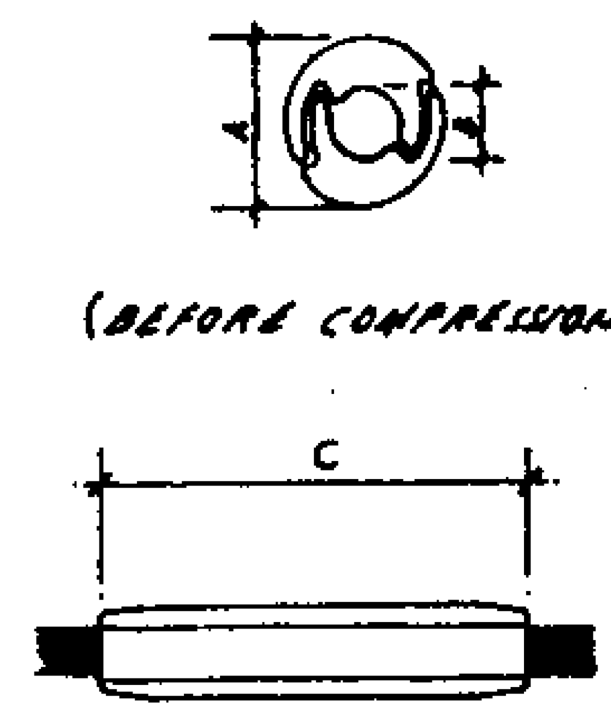
a) Mid span joint & repair sleeve PDW/DF-302

ALUMINIUM STEEL



(BEFORE COMPRESSION)

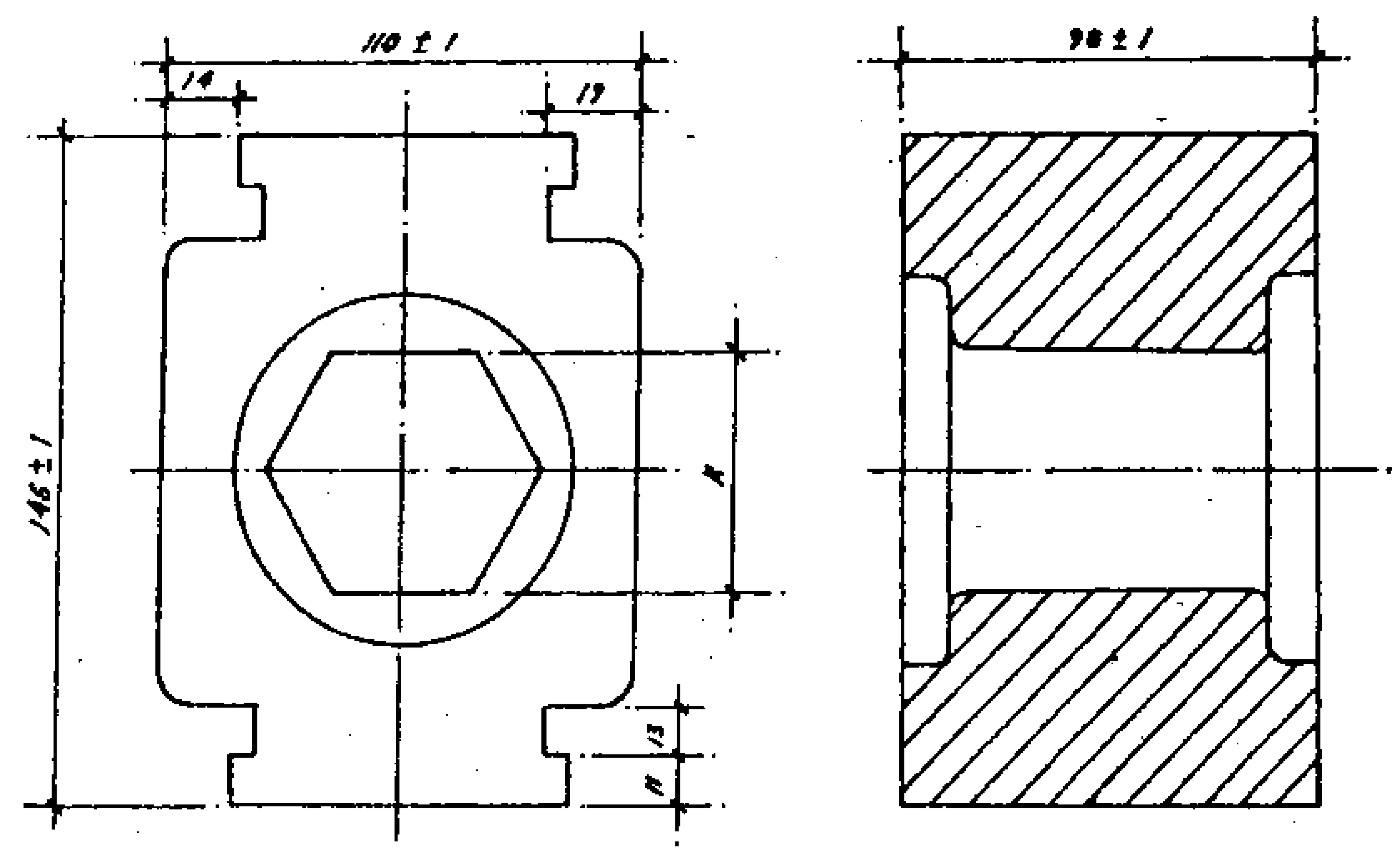
ALUMINIUM COMPRESSION MID SPAN JOINT



(BEFORE COMPRESSION)

(CONDUCTOR REPAIR SLEEVE)

DESCRIPTION	DOG mm	LYNX mm	CUCKOO mm	RAIL mm	CARDINAL mm
CONDUCTOR DIA					
DIA OF COMPLETE COND.	14.2	19.5	27.7	29.6	30.4
DIA OF STEEL CORE	4.7	8.5	9.2	7.4	10.14
AL. JOINT					
OUTSIDE DIA (A)	22.5	34.5	45.5	50.5	54.0
INSIDE DIA (B)	15.5	21.0	29.0	31.0	32.5
LENGTH (d)	275.0	660.0	850.0	850.0	740.0
STEEL JOINT					
OUTSIDE DIA (a)	10.5	20.5	20.5	19.0	20.8
INSIDE DIA (b)	5.5	8.75	9.75	8.0	10.75
LENGTH (e)	130.0	220.0	230.0	200.0	250.0
REPAIR SLEEVE					
OUTSIDE DIA (A)	22.5	34.5	45.5	50.5	54.0
INSIDE DIA (B)	15.5	21.0	29.0	32.0	33.0
LENGTH (C)	300.0	200.0	250.0	150.0	275.0
COMPRESSOR DIES					
FOR AL: (K)	21.5	30.0	39.5	44.0	48.0
FOR STEEL (K)	10.0	17.0	17.0	16.0	17.0



(DIES FOR COMPRESSION JOINTS)

NO	DATE	REVISIONS	BY
1	18-6-82	DIMENSIONS OF ACSR CARDINAL CONDUCTOR ADDED	

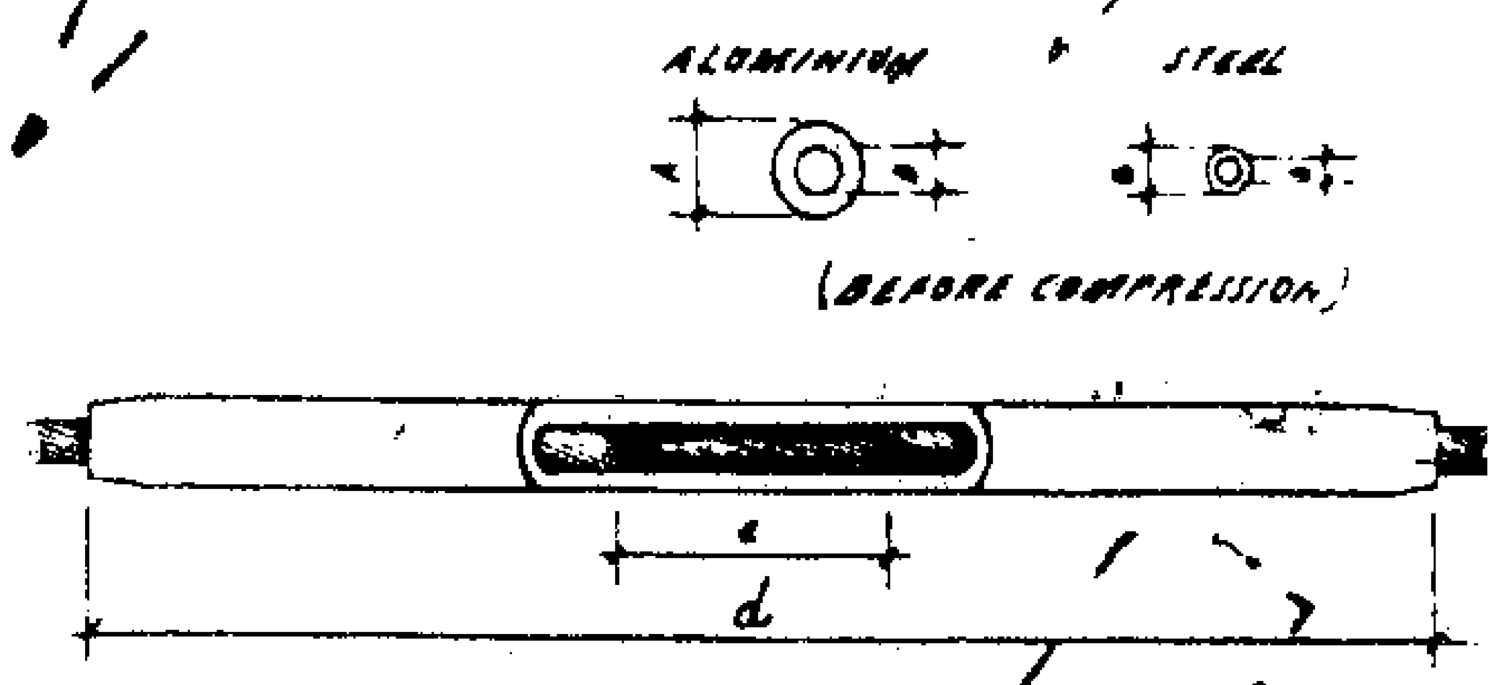
PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY
DESIGN DEPARTMENT

DRAWN	AZHAR SHAH	
CHECKED	GHULAM RASUL	
JUNIOR ENGINEER	MAZAR ABBAS	
SENIOR ENGINEER	MUNAWAR-A-MALIK	
DIRECTOR	S. ISHTIAQ HUSSAIN	
CHIEF ENGINEER	JAVID AKHTAR	

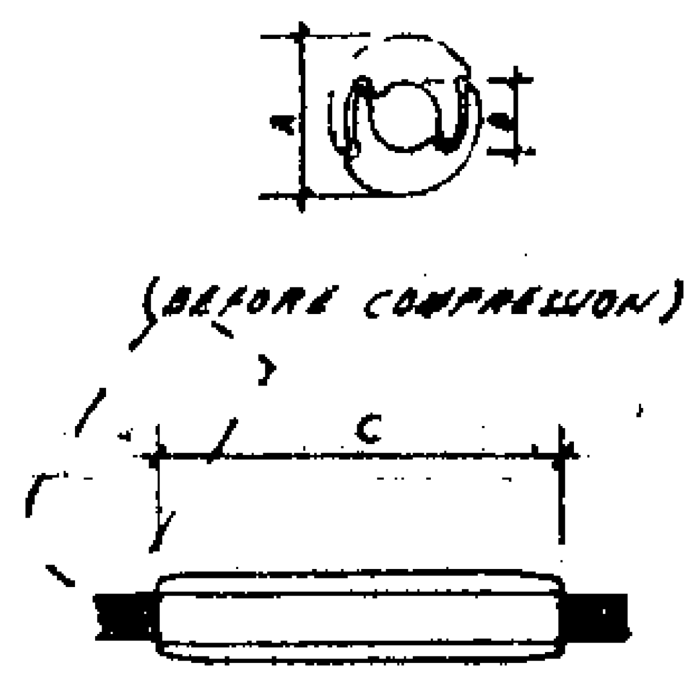
MID SPAN JOINT AND REPAIR SLEEVE

SCALE — DATE 5.2.1980

DWG. NO. PDW/DF-302

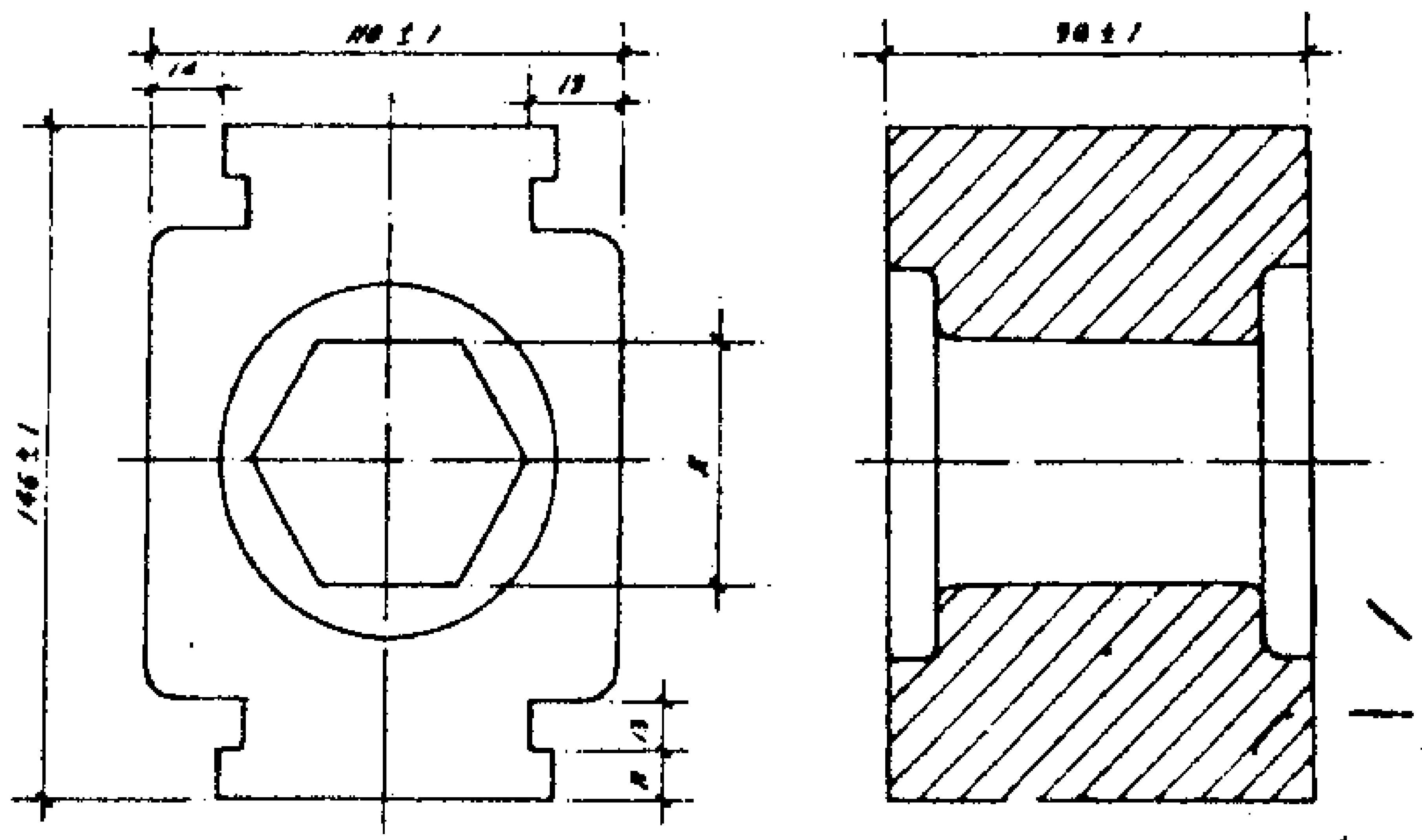


ALUMINIUM COMPRESSION MID SPAN JOINT



(CONDUCTOR REPAIR SLEEVE)

DESCRIPTION	DOG M.M	LYNX M.M	CUCKOO M.M	RAIL M.M
CONDUCTOR DIA				
DIA. OF COMPLETE COND.	14.8	19.5	27.7	29.6
DIA OF STEEL CORE	4.7	8.5	9.2	7.4
AL. JOINT				
OUTSIDE DIA (A)	23.5	34.5	45.5	50.5
INSIDE DIA (B)	15.5	21.0	29.0	31.0
LENGTH (d)	275	660	850	850
STEEL JOINT				
OUTSIDE DIA (a)	10.5	16.5	20.5	19.0
INSIDE DIA (b)	5.5	8.75	9.75	8.0
LENGTH (c)	130	220	230	200
REPAIR SLEEVE				
OUTSIDE DIA (A)	23.5	34.5	45.5	50.5
INSIDE DIA (B)	15.5	21.0	29.0	32.0
LENGTH (C)	200	200	250	250
COMPRESSOR DIES				
FOR AL. (K)	21.5	30.0	39.5	44.0
FOR STEEL (K)	10.6	17.0	17.0	16.0



(DIES FOR COMPRESSION JOINTS)

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY		DESIGN DEPARTMENT
DRAWN	ATHAR SHAH	MID SPAN JOINT AND REPAIR SLEEVE
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CHIEF ENGINEER	JAVID AKHTAR	DWG. NO. PDW/DF-302

SPECIFICATION P-142: 83

STOCK BRIDGE VIBRATION DAMPERS

PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY
DESIGN DEPARTMENT (POWER)

SPECIFICATION P-142: 83

STOCK BRIDGE VIBRATION DAMPERS

AMENDMENT NO.1 DATED 25.11.1990

1. CLAUSE 3.1

   a) Please replace the words "200/400" in third line of this clause with "200 and 400".

   b) Please add the word "respectively" in the end of this clause.

2. CLAUSE 3.2 TABLE-II

   Please read average span length as "320m and 400mm" instead of "320m" against Earthwire 9mm in this table.

C O N T E N T S

PRINTING HISTORY

First approved on 21st September, 1980.
2nd edition in June 1983.
Amendment No. 1 Dated 25.11.1990.

* * * * * * * *

SPECIFICATION P-142: 83

STOCK BRIDGE VIBRATION DAMPERS

0 FOREWORD

0.1 This standard has been introduced by WAPDA and has been prepared by the Transmission Line Section of the Office of the Chief Engineer (Designs).

0.2 This standard is intended only for the purpose of technical specification to facilitate procurement of materials and does not include provision of contract.

0.3 This Specification is subject to periodic revision as and when required.

1 SCOPE

This Specification covers the Stock Bridge Vibration Dampers intended for installation on the 220 kV, 132 kV and 66 kV Lines.

2 TYPE OF STOCK BRIDGE DAMPERS

The stock bridge dampers described in this Specification are of the following types:

TABLE - I

Description	Designation	Conductor or E/W O-D(mm)
a) Stock Bridge Dampers for DOG	SB-D	14.2
b) Stock Bridge Dampers for LYNX	SB-L	19.5
c) Stock Bridge Dampers for CUCKOO	SB-C	27.7
d) Stock Bridge Dampers for RAIL	SB-R	29.6
e) Stock Bridge Dampers for CARDINAL	SB-CA	30.4
f) Stock Bridge Dampers for 9mm E/W Strand	SB-9	9.0
g) Stock Bridge Dampers for 12mm E/W Strand	SB-12	12.0

The hardware described above has been designated by the code Nos. These codes have been assigned in the following manners.

1. The first 2 letters stand for the type of fitting i.e. 'SB' for Stock Bridge Dampers.

2. The succeeding letters indicate the name of conductor whereas numbers indicate the size of E/W i.e. 'D' for DOG conductor and 9 for Earthwire strand of 9mm dia.

3 GENERAL REQUIREMENTS

3.1 Vibration dampers shall be of the Stock Bridge Design and shall effectively suppress aeolian vibration to within 200&400 micro inches per inch peak to peak strain measured for ACSR conductor and earthwire.

3.2 The damper shall be suitable to work in following conditions. No armour rod will be used.

TABLE II

	Name of Wire	O.D dia in mm	Unit wt. kg/m	Rated U.T.S Kg.	E. D Stress (at $23^{o}C$)	Average Span length m	Vibration Frequency range, Hz	No. of Dampers per Span
ACSR	DOG	14.2	0.394	3225	22%	320	12-90	1
"	LYNX	19.5	0.842	8192	22%	320	8.5-65	1
"	CUCKOO	27.7	1.52	12385	22%	400	6-45	1
"	RAIL	29.6	1.60	11874	17%	400	6-45	1
"	CARDINAL	30.4	1.83	15262	17%	700	6-45	2
E/W	9mm	9.0	0.39	5050	17%	320	15-140	1
"	12mm	12.0	0.69	10300	17%	400	12-90	1

Note: The contractor can propose two dampers per span also, in which case the quantities of dampers to be procured will be double.

4 CONSTRUCTION AND DESIGN

4.1 The dampers shall generally comply with the weight and dimensional requirements of the approved drawing. Each damper shall consist of two weights resiliently suspended from the conductor through a suitable clamp conforming to conductor size. The clamp shall be made of high strength anti corrosion aluminium alloy and shall be suitable for hot line maintenance operations. The end of the clamp face shall be smoothly blended to avoid damage to or chafing of conductor when the clamp is applied. The areas of the clamps and weights exposed to high electric stress shall be rounded and smoothly finished to minimise corona emission and radio interefe-rence.

4.2 The damper weights shall be made of cast iron and permanently attached to the messanger wire at its two ends in a manner that mounting remains equidistant from the clamp. The weights, clamp bolts and lock washers shall be galvanised by hot dip process. The messanger wire shall consist of seven strands of high tensile steel wire similar to that used for the steel reinforcement of ACSR Conductors. This wire shall hold the weight firmly and be galvanised, by hot dip process. A drain hole shall be provided in the damper weights to keep the assembly free from any water.

5 TEST

5.1 Type Test

5.1.1 The Contractor shall perform the bending amplitude test for each conductor and Earthwire for the frequency range, span, length and every day stress as given in Table-II both for with and without damper/dampers. A curve shall be plotted to establish the relationship between frequency of vibration versus bending amplitude in mils.

5.1.2 A curve shall be furnished for each type of damper proposed showing the power dissipated by damper versus vibration frequency range for the conditions as indicated in Table-II.

5.1.3 5 certified copies of each curve shall be supplied with the bid.

5.2 Sample Test

i) Visual Examination

ii) Verification of Dimensions

iii) Galvanising Test on ferrous parts

6 TEST METHODS

6.1 Visual Examination

The test samples shall be examined visually for the following defects:

Examination	Defects
Material	Not as specified in relevant clauses.

Examination	Defects
Construction	Not of the shape given in relevant Dwg. Any part missed.
Finish	Galvanising not proper. Presence of burrs, black and bare spots, dross and projections, which will interfere with proper use of the articles.

6.2 Verification of Dimensions

The binding dimensions of the hardware shall be measured and shall be as shown on the relevant approved drawings.

6.3 Galvanising Tests

This test shall be carried out on all ferrous parts complying with the following requirements.

i) Weight of zinc coating

ii) Uniformity of zinc coating

iii) Adherence of zinc coating

This test shall be performed in accordance with WAPDA Specification P-82.(latest revision)

7 SAMPLING PLAN - ACCEPTANCE AND REJECTION

I. Sampling sizes are designated by code letters. Table III shall be used to find the applicable code letter for the particulars lot or batch size for various tests specified in this Specification. While the number of units of product from each lot or batch which are to be inspected (sample size) and the criteria for determining the acceptability of the lot or batch (acceptance & rejection numbers) for different code letters can be obtained from the table-IV given below.

II. The number of sample units inspected shall be equal to the first sample size given in Table-IV. If the number of defective units in the first sample is equal to or less than the first acceptance number, the lot shall be acceptable. If the number of defectives found in the first sample is equal to or greater than the first rejection number, the lot shall be rejected. If the number of defectives found in the first sample is between the first acceptance and rejection number, a second sample of the size given by the plan shall be inspected. The no. of defectives found in the first and the second samples shall be accumulated. If the cumulative no. of defectives is equal to or less than the second acceptance number, the lot shall be acceptable. If the cumulative number of defectives is equal to or greater than the second rejection number, the lot shall be rejected.

TABLE - III

Lot of Batch Size	Sample size for Test specified in Clause 6.3.	Sample size for dimensional and finish defects
2 to 8	A	A
9 to 15	A	B
16 to 25	A	C
26 to 50	A	D
51 to 90	B	E
91 to 150	B	F
151 to 280	B	G
281 to 500	B	H
501 to 1200	C	J

TABLE - IV

Sample size code letters	Sample	Sample size	Cumulative sample size	Acceptance Number	Rejection Number
A	First	1	1	0	1
	Second	-	-	-	-
B	First	2	2	0	2
	Second	2	4	1	2
C	First	3	3	0	2
	Second	3	6	1	2
D	First	5	5	0	2
	Second	5	10	1	2
E	First	8	8	0	2
	Second	8	16	1	2
F	First	13	13	0	3
	Second	13	26	3	4
G	First	20	20	1	4
	Second	20	40	4	5

H	First	32	32	2	5
	Second	32	64	6	7
J	First	50	50	3	7
	Second	50	100	8	9

8 MARKING AND PACKING

The material shall be packed in wooden crates for export shipment to permit convenient handling and to protect against loss or damage to final destination.. Containers (wooden crates) shall be designed for handling by fork-lift, truck and by slings around the container. The weight of each package should be between 100 and 150 kg.

Packages shall be designed for rough handling. All wooden crates shall be clearly marked to indicate.

1. Quantity
2. Name of hardware item
3. Manufacturer's Name

All packages shall be numbered consecutively so that total shipment can be readily determined.

9 INFORMATION TO BE SUPPLIED

The following information shall be supplied with the bid and failure to supply the same may subject the bid to disqualifications:

i) Detailed fully dimensioned drawings of Stock Bridge Dampers.

ii) Specification giving material grade & composition of all parts of Stock Bridge Dampers.

iii) Catalogues/literature of standardised items.

iv) Test Certificates.

v) One complete sample of for all types Stock Bridge Dampers

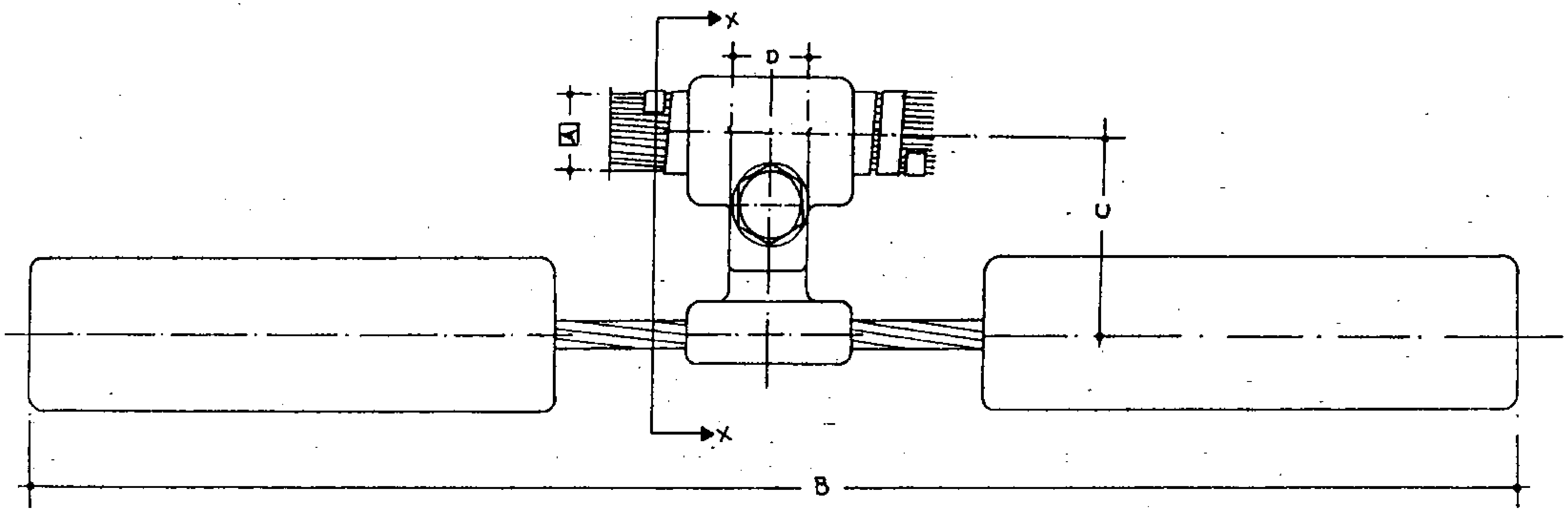
vi) Detail of manufacturing & testing facilities available with manufacturers.

10 DRAWING

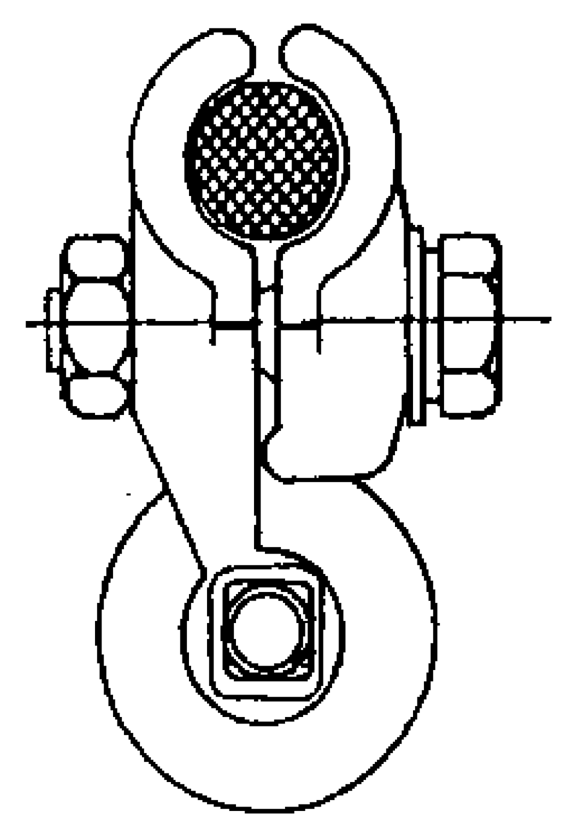
The following drawing form the part of this specification.

a) Stock Bridge Vibration Dampers. PDW/DF-322

m.y



DESCRIPTION	A mm
CARDINAL	30.4
RAIL	29.6
CUCKOO	27.7
LYNX	19.5
DOG	14.2
S/W 9 mm STRAND	9
S/W 12 mm STRAND	12



SECTION X X

DIMENSION MARKED AS B, C & D SHALL BE SUPPLIED ALONG WITH THE WEIGHT OF DAMPER BY THE BIDDER WITH THE OFFER.

▭ INDICATES BINDING DIMENSION.

DIMENSION SHOWN IN MILLIMETRES

NO	DATE	REVISIONS	BY
1	17-8-82	DIMENSION "A" OF ACSR CARDINAL CONDUCTOR ADDED.	

PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY
DESIGN DEPARTMENT

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SENIOR ENGINEER	MUNAWAR-A-MALIK	
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STOCK BRIDGE VIBRATION DAMPER (GENERAL ARRANGEMENT)

SCALE

DATE 27-9-80

DWG: NO. PDW/DF-322

Designation: B 416 – 98

AMERICAN SOCIETY FOR TESTING AND MATERIALS
100 Barr Harbor Dr., West Conshohocken, PA 19428

Standard Specification for Concentric-Lay-Stranded Aluminum-Clad Steel Conductors[1]

This standard is issued under the fixed designation B 416; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers bare concentric-lay-stranded conductors made from bare, hard-drawn, round, aluminum-clad steel wires of 20.3 % conductivity for general use of electrical purposes. This specification does not apply to stranded conductors for reinforcement in ACSR conductors.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

2. Referenced Documents

2.1 The following documents of the issue in effect on date of material purchase form a part of this specification to the extent referenced herein:

2.2 *ASTM Standards:*

B 354 Terminology Relating to Uninsulated Metallic Electrical Conductors[2]

B 415 Specification for Hard-Drawn Aluminum-Clad Steel Wire[2]

2.3 *Other Documents:*

C8.1 Definitions and General Standards for Wires and Cables[3]

NBS *Handbook 100—Copper Wire Tables of the National Institute of Standards and Technology*[4]

3. Description of Conductor

3.1 The designation of the finished conductor shall be expressed as the number of wires and the diameter of these individual wires, usually expressed as the AWG size of the wires.

4. Ordering Information

4.1 Orders for material under this specification shall include the following information:

4.1.1 Quantity of each size,

4.1.2 Conductor size expressed as number and AWG size of individual wires (Section 3 and Table 1),

4.1.3 Direction of lay of outer layer, if other than left-hand (see 6.3),

4.1.4 Package size (see 15.1),

4.1.5 Special package markings if required (see 15.3),

4.1.6 Special lagging if required (see 15.2), and

4.1.7 Place of inspection if other than place of manufacture (Section 13).

5. Joints

5.1 Joints or splices may be made in the finished individual aluminum-clad steel wires composing concentric-lay stranded conductors using more than three wires, provided that such joints or splices have a protection and electrical conductance equivalent to that of the wire itself and that they do not decrease the strength of the finished stranded conductor below the minimum breaking strength shown in Table 1. Such joints or splices shall be not closer than 50 ft (15 m) to any other joint in the same layer in the conductor.

NOTE 1—Joints are made by electrical butt-welding. The ends must be cut and the end of each wire must be straightened for a distance of 12 to 15 in. (300 to 380 mm). The proper sleeve is slipped over the end of one of the wires. The wires are then butt-welded and dressed off to a finished diameter equal to that of the wire. The weld area is then tempered, the sleeve centered over the weld area and compressed to provide a finished joint that is smooth and neat in appearance. This joint has a tensile strength of approximately 90 % of rated breaking strength of the wire, but an allowance is made for this in the rated strength of the conductor as a whole. The completed conductor when containing such joints is required to have the full rated strength.

6. Lay

6.1 For 3-wire conductors, the preferred lay is 16½ times the outside diameter, but the lay shall not be less than 14 times nor more than 20 times this diameter.

6.2 For 7, 19, and 37-wire conductors, the preferred lay is 13½ times the diameter of that layer, but the lay shall not be less than 10 nor more than 16 times this diameter.

6.3 The direction of lay of the outer layer shall be left-hand unless the direction of lay is specified otherwise by the purchaser.

6.4 The direction of lay shall be reversed in consecutive layers.

6.5 All wires in the conductor shall lie naturally in their true positions in the completed conductor. They shall tend to remain in position when the conductor is cut at any point and shall

[1] This specification is under the jurisdiction of ASTM Committee B-1 on Electrical Conductors and is the direct responsibility of Subcommittee B01.06 on Composite Conductors.

Current edition approved March 10, 1998. Published September 1998. Originally published as B 416 – 64 T. Last previous edition B 416 – 93.

[2] *Annual Book of ASTM Standards*, Vol 02.03.

[3] Available from the American National Standards Institute, 11 West 42nd St., 13th Floor, New York, NY 10036.

[4] Available from the National Institute of Standards and Technology, (NIST), Gaithersburg, MD 20899 .

TABLE 1 Construction Requirements and Breaking Strength of Concentric-Lay Stranded Aluminum-Clad Steel Conductors[A]

Size Designation[B]	Number and Diameter of Individual Wires		Conductor Diameter, in.[C]	Rated Breaking Strength min, lb[D]
	Number	Nominal Diameter, in.		
37 No. 5 AWG	37	0.1819	1.27	142 800
37 No. 6 AWG	37	0.1620	1.13	120 200
37 No. 7 AWG	37	0.1443	1.01	100 700
37 No. 8 AWG	37	0.1285	0.899	84 200
37 No. 9 AWG	37	0.1144	0.801	66 770
37 No. 10 AWG	37	0.1019	0.713	52 950
19 No. 5 AWG	19	0.1819	0.910	73 350
19 No. 6 AWG	19	0.1620	0.810	61 700
19 No. 7 AWG	19	0.1443	0.721	51 730
19 No. 8 AWG	19	0.1285	0.642	43 240
19 No. 9 AWG	19	0.1144	0.572	34 290
19 No. 10 AWG	19	0.1019	0.509	27 190
7 No. 5 AWG	7	0.1819	0.546	27 030
7 No. 6 AWG	7	0.1620	0.486	22 730
7 No. 7 AWG	7	0.1443	0.433	19 060
7 No. 8 AWG	7	0.1285	0.385	15 930
7 No. 9 AWG	7	0.1144	0.343	12 630
7 No. 10 AWG	7	0.1019	0.306	10 020
7 No. 11 AWG	7	0.0907	0.272	7 945
7 No. 12 AWG	7	0.0808	0.242	6 301
3 No. 5 AWG	3	0.1819	0.392	12 230
3 No. 6 AWG	3	0.1620	0.349	10 280
3 No. 7 AWG	3	0.1443	0.311	8 621
3 No. 8 AWG	3	0.1285	0.277	7 206
3 No. 9 AWG	3	0.1144	0.247	5 715
3 No. 10 AWG	3	0.1019	0.220	4 532

[A] For metric equivalents: Diameter (mm)—multiply diameter in inches by 25.4 (round to 4 significant figures).

Breaking Strength (kg)—multiply breaking strength in pounds by 0.45359 (round to 4 significant figures).

[B] The designation is a combination of the number of wires each of the AWG size indicated by" No."

[C] Diameter of circumscribing circle. See Table 3 for complete table of properties.

[D] See Section 7.

permit restranding by hand after being forcibly unraveled at the end of the conductor.

7. Strength of Conductor

7.1 The breaking strength of the completed conductors composed of 7 wires, 19 wires, and 37 wires shall be taken as 90 % of the sum of the breaking strengths of the aluminum-clad wires, calculated from their nominal diameter and the appropriate specified minimum tensile strength given in Table 1, Tensile Requirements, of Specification B 415 (20 % column only). The breaking strength of completed conductors composed of 3 wires shall be taken as 95 % of the sum of the breaking strengths of the aluminum-clad wires calculated in the same manner.

8. Construction

8.1 The number and diameter of the wires in the concentric-lay stranded conductors shall conform to the requirements prescribed in Table 1.

NOTE 2—For definitions of terms relating to conductors, reference should be made to ANSI C8.1 and Terminology B 354.

9. Physical and Electrical Tests

9.1 Tests for physical and electrical properties of wires composing concentric-lay stranded conductors made from aluminum-clad steel wire shall be made before stranding.

9.2 At the option of the purchaser, tension and elongation tests before stranding may be waived and the complete conductors may be tested as a unit. The breaking strength of the conductors so tested shall be not less than that required in Table 1.

9.3 Where breaking strength tests are required on the finished conductor, they shall be made on representative samples not less than 4 ft (1.25 m) in length. For lots of 10 000 lb (4540 kg) or less, two samples shall be taken from separate reels or coils in the lot except that but one sample shall be required where the total amount of conductor is 5000 ft (1525 m) or less. For quantities over 10 000 lb, one sample for each 10 000 lb or fraction thereof, shall be taken, but the minimum number of samples shall be three.

9.4 Specimens of the completed conductor shall be tested in a tension testing machine equipped with jaws suitable for gripping the conductor or equipped for holding properly socketed specimens. Any test in which the result is below the stated value, and which is obviously caused by improper socketing of the specimen or due to the break occurring in or at the gripping jaws of the machine, shall be disregarded and another sample from the same coil or reel shall be tested.

10. Density

10.1 For the purpose of calculating mass per unit length (see Note 4), cross-sections, etc., the density of the aluminum-clad steel wire shall be taken as 0.2381 lb/in.^{3}(6.590 g/cm^3) at 20°C (Note 3). Other constants are given in Table 2.

NOTE 3—The value of the density of aluminum-clad steel wire is an average value which has been found to be in accordance with usual values encountered in practice.

NOTE 4—The term mass per unit length is used in the specification as being more technically correct. It replaces the terms "weights" and "linear density".

11. Mass and Resistance

11.1 The mass and electrical resistance of a stranded conductor are greater than the total of the same characteristics of the wires composing the conductors, depending upon the lay or pitch. The standard increment of mass and resistance shall be taken as shown in Table 3.

11.2 In cases where the lay is definitely known, the increment may be calculated if desired.

NOTE 5—The increment of mass or electrical resistance of a completed concentric-lay stranded conductor, *K,* in percent is

$$K = 100\,(m - 1)$$

where m is the stranding factor, and is also the ratio of the mass or electrical resistance of a unit length of stranded conductor to that of a solid conductor of the same cross-sectional area or of a stranded conductor with infinite length of lay; that is, all wires parallel to the conductor axis. The stranding factor m for the completed, stranded conductor is the numerical average of the stranding factors for each of the individual wires in the conductor, including the straight core wire, if any (for which the stranding factor is unity). The stranding factor (m_{ind}) for any given wire in a concentric-lay stranded conductor is

$$m_{ind} = \sqrt{1 + (9.8696/n^2)}$$

where n = length of lay/diameter of helical path of the wire

TABLE 2 Approximate Properties of Concentric-Lay Stranded Aluminum-Clad Steel Conductors (for information only)[A]

No. and Size of Wires	Conductor Diameter, in.	Rated Breaking Strength, min, lb	Mass per Unit Length		Resistance at 20°C max, Ω/1000 ft	Nominal Cross Section	
			lb/1000 ft	lb/mile		cmils	in.^{2}
37 No. 5 AWG	1.27	142 800	2 802	14 800	0.04247	1 225 000	0.9619
37 No. 6 AWG	1.13	120 200	2 222	11 730	0.05356	971 300	0.7629
37 No. 7 AWG	1.01	100 700	1 762	9 305	0.06754	770 300	0.6050
37 No. 8 AWG	0.899	84 200	1 398	7 379	0.08516	610 900	0.4798
37 No. 9 AWG	0.801	66 770	1 108	5 852	0.1074	484 400	0.3805
37 No. 10 AWG	0.713	52 950	879.0	4 641	0.1354	384 200	0.3017
19 No. 5 AWG	0.910	73 350	1 430	7 552	0.08224	628 900	0.4940
19 No. 6 AWG	0.810	61 700	1 134	5 990	0.1037	498 800	0.3917
19 No. 7 AWG	0.721	51 730	899.5	4 750	0.1308	395 500	0.3107
19 No. 8 AWG	0.642	43 240	713.5	3 767	0.1649	313 700	0.2464
19 No. 9 AWG	0.572	34 290	565.8	2 987	0.2079	248 800	0.1954
19 No. 10 AWG	0.509	27 190	448.7	2 369	0.2622	197 300	0.1549
7 No. 5 AWG	0.546	27 030	524.9	2 772	0.2264	231 700	0.1820
7 No. 6 AWG	0.486	22 730	416.3	2 198	0.2803	183 800	0.1443
7 No. 7 AWG	0.433	19 060	330.0	1 743	0.3535	145 700	0.1145
7 No. 8 AWG	0.385	15 930	261.8	1 382	0.4458	115 600	0.09077
7 No. 9 AWG	0.343	12 630	207.6	1 096	0.5621	91 650	0.07198
7 No. 10 AWG	0.306	10 020	164.7	869.4	0.7088	72 680	0.05708
7 No. 11 AWG	0.272	7 945	130.6	689.4	0.8938	57 590	0.04523
7 No. 12 AWG	0.242	6 301	103.6	546.8	1.127	45 710	0.03590
3 No. 5 AWG	0.392	12 230	224.5	1 186.0	0.5177	99 310	0.07800
3 No. 6 AWG	0.349	10 280	178.1	940.2	0.6528	78 750	0.06185
3 No. 7 AWG	0.311	8 621	141.2	745.6	0.8232	62 450	0.04905
3 No. 8 AWG	0.277	7 206	112.0	591.3	1.038	49 530	0.03890
3 No. 9 AWG	0.247	5 715	88.81	468.9	1.309	39 280	0.03085
3 No. 10 AWG	0.220	4 532	70.43	371.8	1.651	31 150	0.02446

Coefficient of linear expansion	(0.0000072/°F) (0.0000126/°C)
Final modulus of elasticity	23 000 000 psi (160 GPa)
Temperature coefficient of resistance	(0.0020/°F) (0.0036/°C)

[A] For metric equivalents:
Diameter (mm)—multiply diameter in inches by 25.4 (round to 3 significant figures);
Rated Breaking Strength (kg)—multiply rated breaking strength in pounds by 0.45359 (round to 4 significant figures);
Mass/Unit Length in kg/km—multiply mass/unit length in pounds per 1000 feet by 1.48816 (round to 4 significant figures);
Resistance (ohms/km)—multiply resistance in ohms per 1000 feet by 3.281 (round to 4 significant figures);
Nominal Cross Section (mm^2)—multiply cross section in square inches by 645.16 (round to 4 significant figures).

TABLE 3 Standard Increments Due to Stranding

Type of Conductor	Increment (Increase) of Resistance and Mass, %
3-wire	0.8
7-wire	1.0
19-wire	1.4
37-wire	2.0

The derivation of the above is given in *NBS Handbook 100.*

12. Requirements for Wires

12.1 Before stranding, the aluminum-clad steel wires shall meet all the requirements of Specification B 415 (20.3 % conductivity only).

13. Inspection

13.1 Unless otherwise specified in the contract or purchase order, the manufacturer shall be responsible for the performance of all inspection and test requirements specified.

13.2 All inspections and tests shall be made at the place of manufacture unless otherwise agreed to between the manufacturer and the purchaser at the time of the purchase.

13.3 The manufacturer shall afford the inspector representing the purchaser all reasonable manufacturer's facilities necessary to ensure that the material is being furnished in accordance with this specification.

14. Rejection

14.1 If the conductor fails in the first test to meet any requirement of this specification, two additional tests for these requirements shall be made on samples of conductor from the same coil or reel. If failure occurs in either of these tests, the lot of conductor shall be rejected. However, the lot may be resubmitted for inspection by testing every coil or reel for the requirement in which the specimen failed and sorting out the defective coils or reels.

15. Packaging and Package Marking

15.1 Lengths of conductor, reel sizes, or coils shall be agreed upon between the manufacturer and the purchaser at the time of placing individual orders.

15.2 When ordered on reels, the material shall be properly packaged to prevent damage to the conductor in ordinary handling and transportation. If wood lagging is required, it shall be specified at the time of purchase by the purchaser. Each reel shall contain one continuous length.

15.3 A weather-resistant tag shall be attached to the outside of each coil or reel showing the manufacturer's name or trademark with the net mass, length, and size of conductor. If additional information is required on the tags, it shall be arranged with the manufacturer at the time of purchase. Each coil shall also have a tag inside the wrapping showing the manufacturer's name, the net mass, length and size of conductor.

16. Keywords

16.1 aluminum electrical conductor—aluminum-clad steel; aluminum electrical conductor—stranded; aluminum-clad steel electrical conductors; clad steel electrical conductor; concentric-lay-stranded aluminum-clad steel electrical conductors; electrical conductor

SPECIFICATION P-141: 80

TRANSMISSION LINE EARTHWIRE FITTINGS

PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY
Design Department (T&G) Power

C O N T E N T S

PRINTING HISTORY

First approved on 21st September, 1980.

SPECIFICATION P-141: 80

TRANSMISSION LINE EARTHWIRE FITTINGS

0 FOREWORD

0.1 This standard has been introduced by WAPDA and has been prepared by the Transmission Line Section of the office of the Chief Engineer (Design).

0.2 This standard is intended only for the purpose of technical specification to facilitate procurement of materials and does not include provision of contract.

0.3 This Specification is subject to periodic revision as and when required.

1 SCOPE

This Specification covers the hardware required for suspension and tension fittings and midspan joints of earthwire.

2 TYPES OF EARTHWIRE FITTINGS AND MIDSPAN JOINT

The fittings and joint described in this specification are of the following types:

	Description	Designation
a)	Suspension clamp for 9 mm strand	SF-9
b)	Suspension clamp for 12 mm strand	SF-12
c)	Tension fittings for 9 mm strand	TF-9
d)	Tension fittings for 12 mm strand	TF-12
e)	Midspan joints for 9 mm strand	MS-9
f)	Midspan joints for 12 mm strand	MS-12

The hardware described above has been designated by the code Nos. These codes have been assigned in the following manners:

i) The first 2 letters stand for type of fitting i.e. 'SF' for suspension fittings, 'TF' for tension fittings and 'MS' for midspan joints.

ii) The No. after the letters indicate the overall diameter of earthwire.

3 RATINGS OF HARDWARE

3.1 The hardware shall be of the ratings as specified in Table-II below:

Table-II RATINGS OF HARDWARE

Sr. No.	Description	SF-9	SF-12	TF-9	TF-12	MS-9	MS-12
1.	Suspension clamp vertically applied load.	5000	10300	-	-	-	-
2.	Shackle	-	-	5000	10300	-	-
3.	Tension clamp	-	-	5000	10300	-	-
4.	Mid span joint	-	-	-	-	5000	10300

4 GENERAL REQUIREMENTS

4.1 Each tension fittings of earthwire shall consist of

2 Shackle
2 Tension Clamp
1 Earthing Clamp

4.2 All ferrous parts shall be hot dip galvanized in accordance with WAPDA Specification P-82: (latest revision)

4.3 The parts of hardware that mate with each other, shall not have a play clearance of more than 2 mm.

5 DIMENSIONS AND TOLERANCES

All hardware shall generally be in accordance with drawings forming a part of this Specification.

The dimensions of these parts of hardware that mate with other hardware or that determine the length of insulator string are binding and are shown enclosed on the drawing.

For dimensions that are fixed and binding the tolerance will be plus or minus 2 percent with a maximum of 0.8mm. For dimensions that are shown as Max or Min there shall be no plus and minus tolerance respectively. The tolerance in the opposite sense may however be 4%.

6 DESIGN AND MATERIAL

6.1 Earthwire Suspension Clamp

These clamps are specifically used for the suspension of steel earthwire. The clamp consists of the following items.

6.1.1 Body and Keeper

The bodies and keepers of ground wire suspension clamps shall be made of hot dip galvanised steel, and the cotter pins of stainless steel or of copper alloy. Ends of the clamp body shall be curved to accommodate to take an angle of 50 degrees without causing any sharp bond in the wire. All surfaces shall be smooth and free from burrs or other manufacturing defects. Clamps shall be furnished with double hole trunnion U-bolt suspension and copper bond for earthing to tower body. The clamp shall be according to Dwg. No. PDW/DF-320.

6.1.2 Split Pin

Split pins are used as locking devices which prevent falling out of ball pin from the socket under any working conditions. They shall be made from half round brass wire protected against corrosion by appropriate coating and shall be able to work under hot line conditions.

6.2 Earthwire Tension Clamp

These clamps are made from hot dip galvanised high grade forged steel and are suitable for clamping earthwire without having to cut it. These clamps are composed of two plates with slightly corrugated seat, connected with strong U-bolts. This clamp shall be in accordance with Dwg. No. PDW/DF-321.

6.3 Earthing Clamp

These clamps are made from hot dip galvanised, malleable iron. These clamps are also composed of two plates with slightly corrugated seat connected with a U-bolt. It shall be in accordance with Dwg. No. PDW/DF-321.

6.4 Shackle

These shall be made from forged steel hot dip galvanised and shall be according to Dwg. No. PDW/DF-321.

6.5 Midspan Joints

Midspan joints shall be of the compression type. They shall be such that after compression they shall assume a hexagonal cross-section.

Earthwire joints shall be made of hot dip galvanised steel. They shall be made according to Dwg. No. PDW/DF-330.

7 TESTS

7.1 Type Tests

7.1.1 Type tests are intended to verify and establish design characteristics. They shall be made once only on hardware indentical in all essential details with those to be supplied.

The following type tests shall be carried out in accordance with clauses 10 & 11.

i)	Mechanical Test	On each individual item of hardware.
ii)	Resistance to conductor slippage test	On tension clamps and midspan joints only.

7.2 Sample Tests

Sample tests shall be made to verify the quality and workmanship.

The following sample test shall be performed in accordance with clauses 8, 9, 10, 11 & 12.

i)	Visual examination	On each item of hardware
ii)	Verification of dimensions	On each item of hardware
iii)	Mechanical test	On each item of hardware
iv)	Resistance to conductor slippage test	On tension clamps and midspan joints only.
v)	Galvanising test	On all ferrous parts

8 VISUAL EXAMINATION

The test samples shall be examined visually for the following defects:

Visual Examination

Examination	Defects
Material	Not as specified in relevant clauses.
Construction	Not of the shape given in relevant drawing. Any part missing.
Finish	Galvanising not proper. Presence of burrs, black and bare spots, dross and projections, which will interfere with proper use of the articles.

9 VERIFICATION OF DIMENSIONS

The binding dimensions of the hardware shall be measured and shall be as shown on the relevant approved drawings subject to the tolerance given in clause 5.

10 MECHANICAL TEST

The fitting shall be held in tensile testing machine in a manner approximating as nearly as possible to the arrangement to be used in service.A Tensile load equal to one-half of the specified minimum failing load shall be applied and increased at a steady rate. Failure of the fitting shall not occur at a load less than the specified minimum failing load as per Table-II.

11 RESISTANCE TO SLIPPAGE TEST

Test piece shall be assembled in accordance with manufacturer's recommendations on earthwire of the size and type with which it is to be used. The assembly shall be mounted in a tensile testing machine and anchored in a manner approximating as nearly as possible to the arrangement to be used in service. The length of earthwire joint in the test assembly should preferably be not less than 100 times the overall diameter of the earthwire.

A tensile load of about 50% of the minimum failing load of earthwire specified in table-I shall be applied and the earthwire shall be marked in such a way that movement relative to the fitting can easily be detected without any subsequent adjustment of the fitting, the load shall be steadily increased to 95% of the minimum failing load and then reduced to 90% of the minimum failing load and maintained for 1 minute. There shall be no movement of the earthwire relative to the fitting due to slip during this 1 minute period and no failure of the fitting.

12 GALVANISING TEST

This test shall be carried out on all ferrous parts complying with the following requirements.

i) weight of zinc coating

ii) uniformity of zinc coating

iii) adherence of zinc coating

This test shall be performed in accordance with WAPDA Specification P-82: (latest revision)

13 SAMPLING PLAN - ACCEPTANCE AND REJECTION

I. Sampling sizes are designated by code letter. Table-III shall be used to find the applicable code letter for the particulars lot or batch size for various tests

C

specified in this specification. While the number of units of product from each lot or batch which are to be inspected (sample size) & the criteria for determining the acceptability of the lot or batch (acceptance & rejection numbers) for different code letters can be obtained from the table-IV given below.

II. The number of sample units inspected shall be equal to the first sample size givenin Table-IV. If the number of defective units found in the first sample is equal to less than the first acceptance number, the lot shall be acceptance. If the number of defectives found in the first sample is equal to or greater than the first rejection number, the lot shall be rejected. If the number of defectives found in the first sample is between the first acceptance and rejection number, a second sample of the size given by the plan shall be inspected. The No. of defectives found in the first & the second samples shall be accumulated. If the cumulative No. of defectives is equal to or less than the second acceptance number, the lot shall be acceptable. If the cumulative No. of defectives is equal to or greater than the second rejection number, the lot shall be rejected.

TABLE-III

Lot or Batch Size	Sample size for Test specified in Clause 10,11 & 12	Sample size for dimentional and finish defects
1	2	3
2 to 8	A	A
9 to 15	A	B
16 to 25	A	C
26 to 50	A	D
51 to 90	B	E
91 to 150	B	F
151 to 280	B	G
281 to 500	B	H
501 to 1200	C	J

TABLE - IV

Sample size code letters	Sample	Sample size	Cumulative sample size	Acceptance number	Rejection number
A	First	1	1	0	1
	Second	-	-	-	-

Sample size code letters	Sample	Sample size	Cumulative sample size	Acceptance number	Rejection number
B	First	2	2	0	2
	Second	2	4	1	2
C	First	3	3	0	2
	Second	3	6	1	2
D	First	5	5	0	2
	Second	5	10	1	2
E	First	5	5	0	2
	Second	8	16	1	2
F	First	13	13	0	3
	Second	13	26	3	4
G	First	20	20	1	4
	Second	20	40	4	5
H	First	32	32	2	5
	Second	32	64	6	7
J	First	50	50	3	7
	Second	50	100	8	9

14 MARKING AND PACKING

The material shall be packed in wooden crates for export shipment to permit convenient handling and to protect against loss or damage to final destination. Containers (wooden crates) shall be designed for handling by fork-lift, truck and by slings around the container. The weight of each package should be between 100 and 150 kg.

Packages shall be designed for rough handling. All wooden crates shall be clearly marked to indicate.

1. Quantity
2. Name of hardware item
3. Manufacturer's name

All packages shall be numbered consecutively so that total shipment can be readily determined.

15 INFORMATION TO BE SUPPLIED

The following information shall be supplied with the bid and failure to supply the same may subject the bid to disqualifications:

i) Detailed fully dimensioned drawings of earthwire fitting and midspan joint.

ii) Specification giving material grade & composition of all items of hardware.

iii) Catalogues/literature of standardised items.

iv) Test certificates.

v) One complete sample of all types of earthwire fittings and midspan joint.

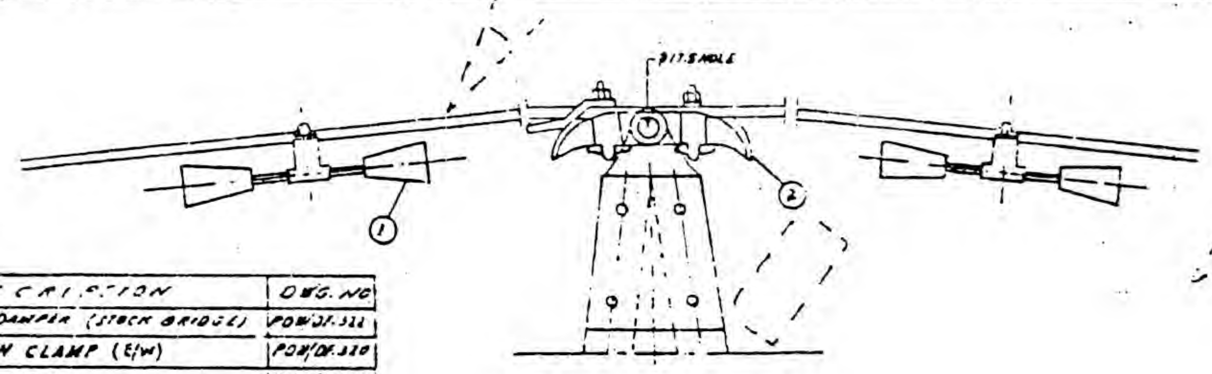
vi) Detail of manufacturing & testing facilities available with manufacturers.

16 DRAWINGS

The following drawings form the part of this Specification.

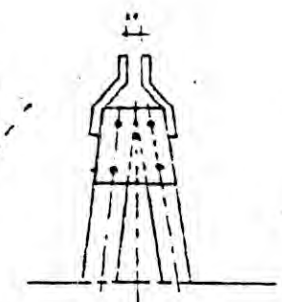
a)	Earthwire Suspension and Tension Assemblies	PDW/DF-319
b)	Earthwire Suspension Clamp	PDW/DF-320
c)	Earthwire Tension Fittings	PDW/DF-321
d)	Earth wire mid span joint	PDW/DF-330

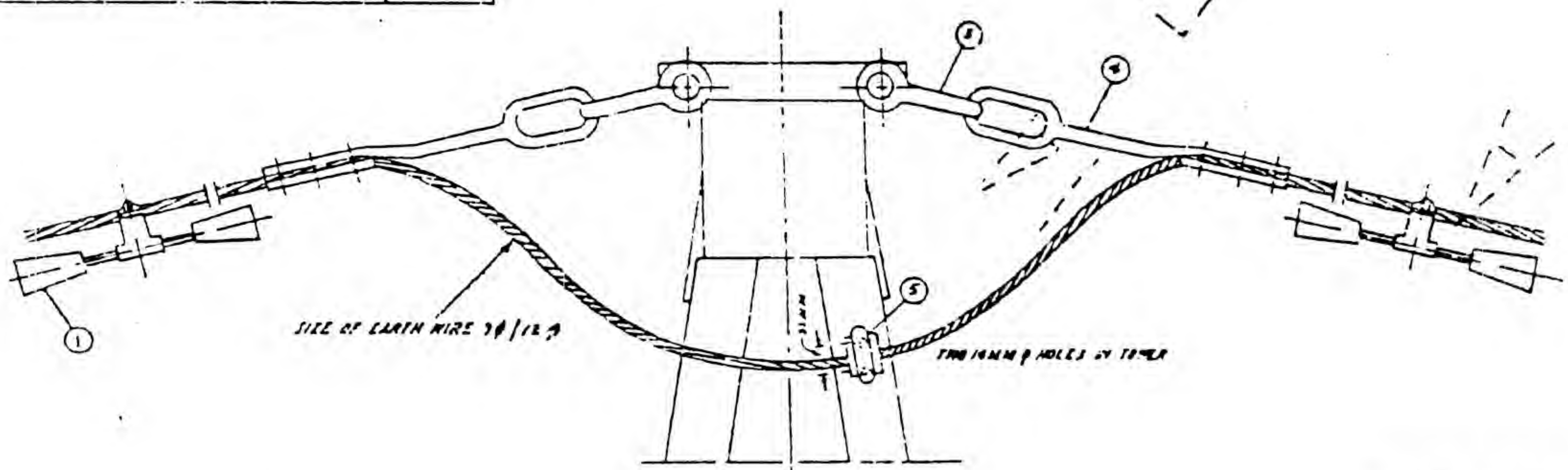
m.y



SUSPENSION ARRANGEMENT

ITEM	QTY	DESCRIPTION	DWG. NO
1.	2	VIBRATION DAMPER (STOCK BRIDGE)	POW/DF.322
2.	1	SUSPENSION CLAMP (E/W)	POW/DF.320
3	2	SHACKLE (E/W)	POW/DF.321
4	2	TENSION CLAMP (E/W)	POW/DF.324
5	1	EARTHING CLAMP	POW/DF.321





TENSION ARRANGEMENT

DIMENSION SHOWN IN MILLIMETRES

NO	DATE	REVISIONS	BY

PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY
DESIGN DEPARTMENT

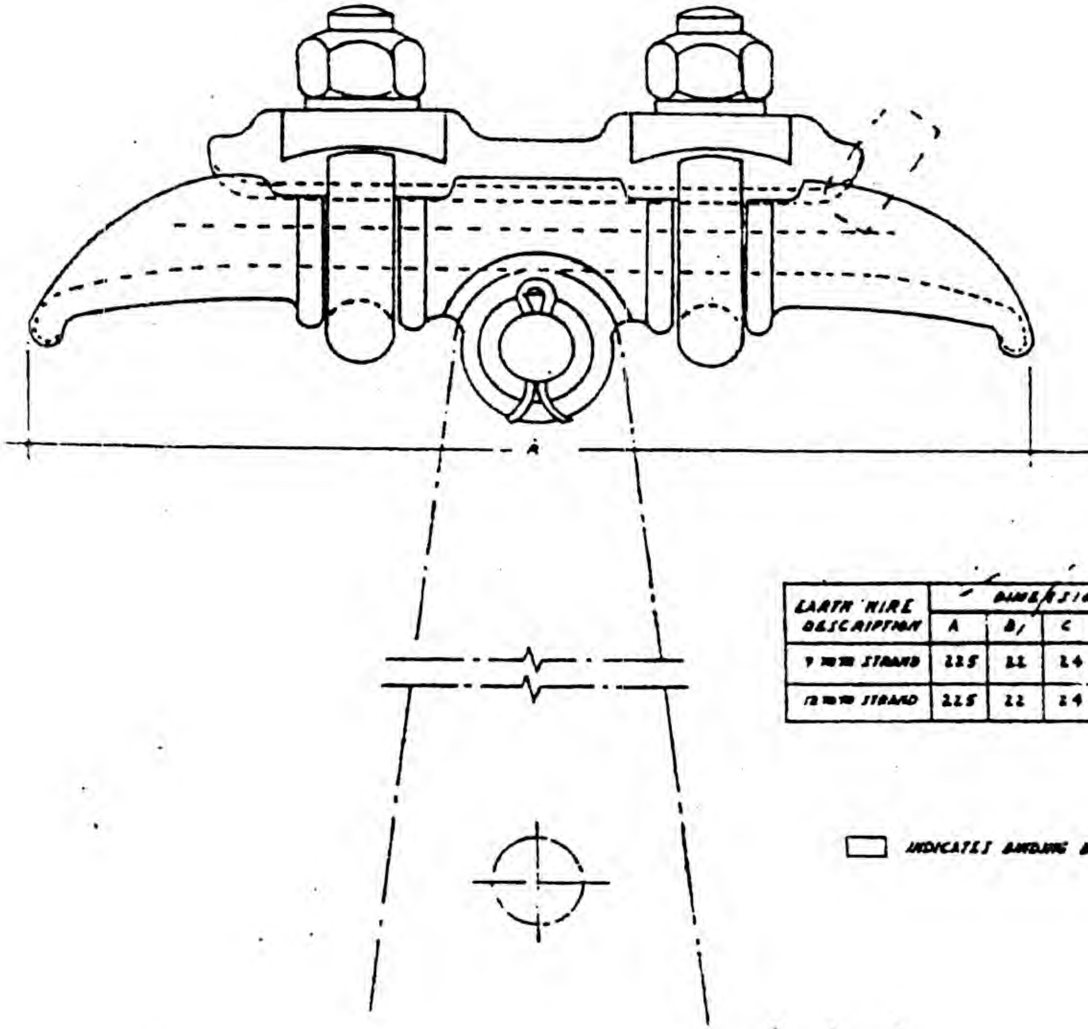
DRAWN	AZHAR SHAH	
CHECKED	ABDUL RAZAQ	
JUNIOR ENGINEER	HASAN ABBAS	
SENIOR ENGINEER	MUHAMMAD MALIK	
DIRECTOR	[illegible] HUSSAIN	
CHIEF ENGINEER	JAVID AKHTER	

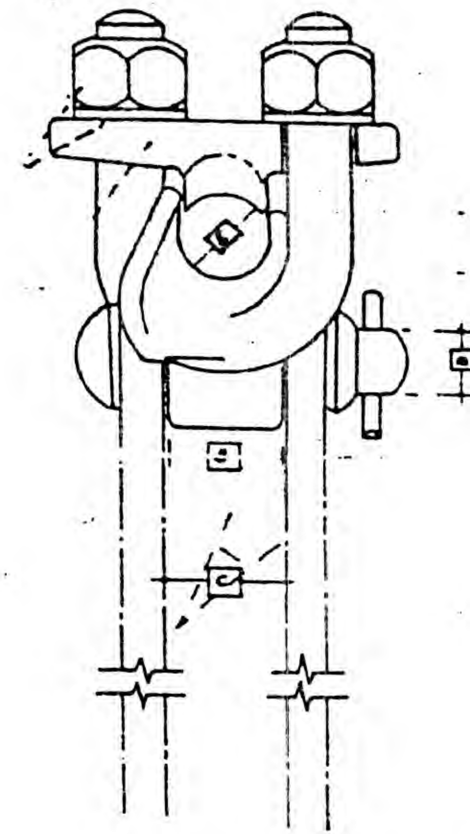
EARTH WIRE SUSPENSION AND TENSION ASSEMBLIES

SCALE

DATE 27-9-89

DWG. NO. POW/DF-317





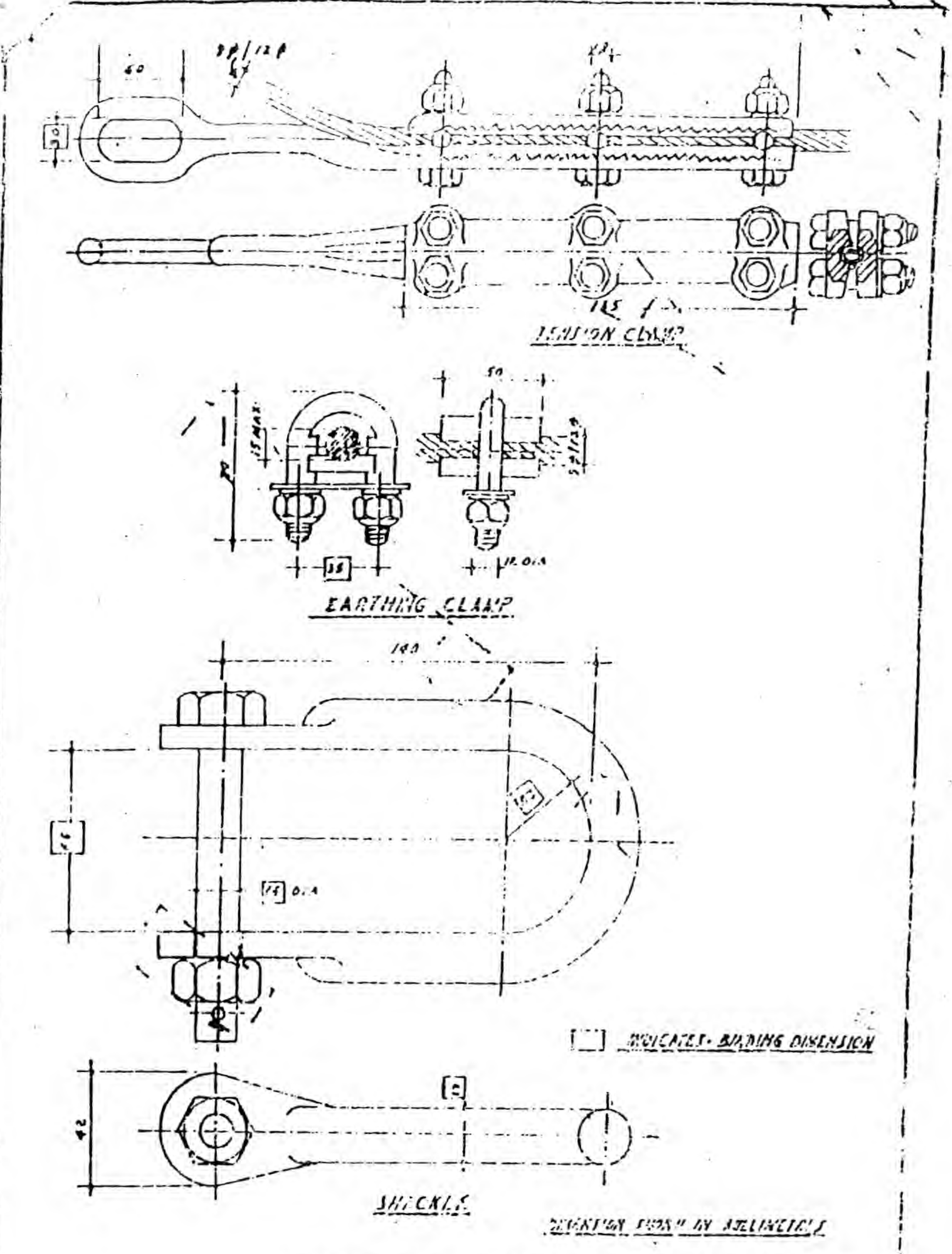
EARTH WIRE DESCRIPTION	DIMENSIONS				
	A	B	C	D	E
7 mm STRAND	225	22	24	16	9
12 mm STRAND	225	22	24	16	12

▭ INDICATES BINDING DIMENSIONS

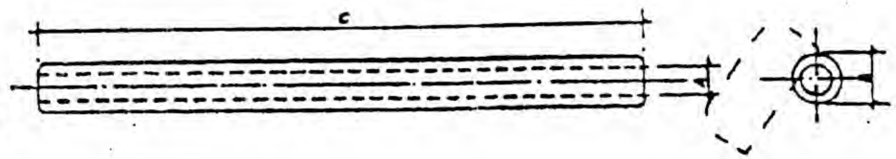
DIMENSION SHOWN IN MILLIMETRES

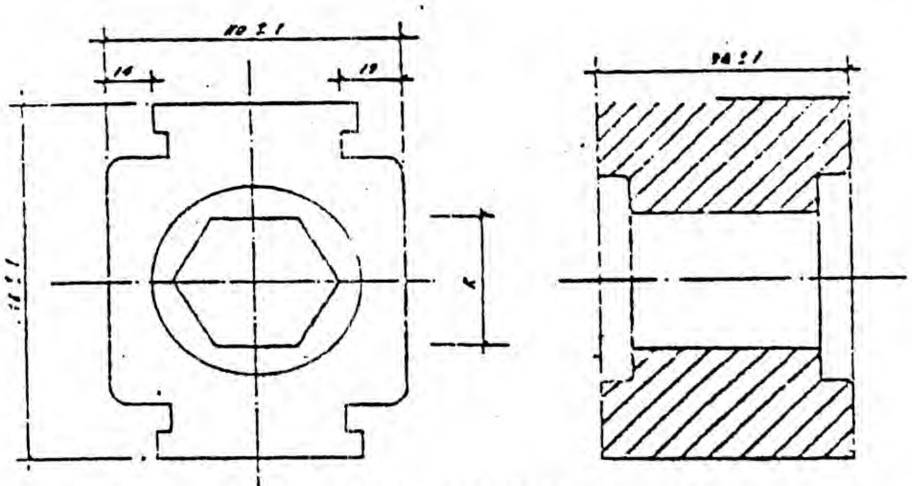
NO	DATE	REVISIONS

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY			DESIGN DEPARTMENT
DRAWN	AZHAR KHAN		EARTH WIRE SUSPENSION CLAMP
CHECKED	GHULAM RASUL		
JUNIOR ENGINEER	HASAN ABBAS		
SENIOR ENGINEER	MUNAWAR-A-MALIK		
DIRECTOR	S. ISHTIAQ HUSSAIN		SCALE — DATE - 5-86
CHIEF ENGINEER	JAVID AKHTER		DWG. NO. PDW/DF-320



PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY			DESIGN DEPARTMENT
DRAWN	AZHAR SHAH		EARTH WIRE TENSION FITTINGS
CHECKED	GHULAM RASUL		
JUNIOR ENGINEER	NAZAR ABBAS		
SENIOR ENGINEER	MUNAWAR-A-MALIK		
DIRECTOR	S ISHTIAQ HUSSAIN		SCALE . DATE 27-5-80
CHIEF ENGINEER	JAVID AKHTAR		DWG. NO. PDW/DF-321





(DIES FOR COMPRESSION JOINTS)

DIAMETER OF EARTHWIRE (mm)	DIMENSIONS			
	A	B	C	K
20	9.3	18.0	203.0	15.0
12.0	12.2	24.0	248.0	20.0

NO.	DATE	REVISIONS	BY

PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY
DESIGN DEPARTMENT

DRAWN	AZHAR IQBAL	
CHECKED	GHULAM RASUL	
JUNIOR ENGINEER	NAZAR ABBAS	
SENIOR ENGINEER	[illegible]	
DIRECTOR	[illegible]	

EARTH WIRE
MID SPAN JOINT

SCALE — DATE 7-[illegible]-1984

DRG. NO. PDF/DF-330

15

SPECIFICATION P-16:68
(UDC 621.315.512)

COPPER WIRE FOR EARTHING

Revised Jan:1968

PAKISTAN

WATER AND POWER DEVELOPMENT AUTHORITY

DESIGN DEPARTMENT (T&G)

C O N T E N T S

PRINTING HISTORY

First revised on 16th January, 1968.

..*.*.*.*.

SPECIFICATION P-16: 68

COPPER WIRE FOR EARTHING

C FOREWORD

0.1 This standard has been prepared by the Engineering Department Power Wing WAPDA.

0.2 This specification is subject to revision as and when required.

0.3 This standard is intended only for the purpose of procurement of material and does not include the provisions of contract

1 SCOPE

1.1 This specification covers the following sizes of medium hard drawn copper wire for earthing purposes:

i) 4.0 mm wire (solid)

ii) 5.5 mm wire (solid)

iii) 6.5 mm wire (solid)

iv) 13 mm strand (7/4.2 mm)

2 MATERIAL

2.1 The material shall be copper of such quality and purity that the finished product shall have the properties and characteristics described in this specification.

2.2 No joints shall be made in the complete wire.

2.3 The wire shall be clean, smooth and free from harmful defects.

2.4 The wire entering into the construction of stranded conductors, shall, bwforw stranding, satisfy all the requirements of this standard.

2.5 The lay ratio of 13 mm strand (7/4.2 mm) shall be not less than 20 or greater than 25.

3 CHARACTERISTICS

3.1 The copper wires shall have the following characteristics.

Dia. mm	Min. Tensile Strength kg/mm.	Max. Tensile Strength kg/mm.	Resistance ohms/k meter at 20°C	Elongation in 25 cm	Elongation in 150 cm	Weight kg/km
4.0	33	38	1.407	-	1%	112.34
5.5	33	38	0.745	-	1.75%	212.4
6.5	33	38	0.533	2.50%	-	296.66
13	33	38	0.184	-	1%	874.20

4 TESTS

4.1 All tests shall be carried out at the manufacturer's works. The necessary testing equipment and assistance shall be provided by the manufacturer free of cost.

4.2 Test Samples

4.2.1 Test samples for determination of compliance this specification shall be taken from each lot of material offered for acceptance. The minimum number of samples to be taken from each lot shall be as follows:

No. of coils/reels in lot	No. of coils/reels in samples
1 to 50	14
51 to 100 inclusive	19
101 to 200 inclusive	24
201 to 400 inclusive	29
401 to 800 inclusive	33
Over 800	34

From each sample, coil test specimen of sufficient length shall be removed and shall be subjected to all the tests prescribed in clause 4.3 of this specification.

4.2.2 Sample shall normally be cut from the end but may also at the direction of the inspector, be cut from any part of a coil, samples thus cut shall not be welded or jointed together, but each length shall be bound into a separate coil. These samples will be accepted if the wire satisfies all the requirements of this specification.

4.3 The following tests shall be carried out on solid conductors of all diameters and on the component wires of standard conductor.

i) Tensile test

ii) Elongation test

iii) Resistance test

4.3.1 Tensile Test

4.3.1.1 The load shall be applied gradually and the rate of separation of the jaws of the testing machine shall be not greater than 10 cm per minute, and shall be so adjusted that the total time of testing from the moment of application of the load till fracture is between 15 and 60 secomds. The minimum and maximum tensile strength of the wire when so tested shall be as specified in clause 3.1.

In case of 13 mm strand test shall be made before stranding. If it is not possible to test the component of wires before stranding the tensile strength of any wire shall not be less than 92.5% of the value given in clause 3.1 and the average strength of all the wires in a stranded conductor shall not be less than 94% of the value specified in clause 3.1.

4.3.2 Elongation Test

4.3.2.1 The load shall be applied on the straightened wire length of 25 cm. The extension shall be measured on the wire after the fracture ends have been fitted together provided that the fracture occurs between the gauge marks and not closer than 25 mm to either mark. If the fracture occurs out-side these limits and if the required elomgation is not obtained, the test shall be discarded and an other test made.

4.3.3 Resistance Test

4.3.3.1 The electrical resistance in ohms per kilometre for a temperature of 20° C shall be calculated to three decimal places in accordance with "International Electrotechnical Commission Publication No. 28" "International strandard of resistance for copper.

.3.3.2 The calculated value shall not be greater than the value specified in clause 3.1 of this specification.

PACKING

.1 The solid copper wire of 4 mm and 5.5 mm diameters shall be supplied in coils,and each coil shall weigh apporoximately 100 kg.

The wire shall be protected against damage in ordinary handling and transport.

5.. The eye of the coil shall not be less than 60 cm.

5.3 Each coil shall be securely bound with three separate binders.

5.4 'he coil shall be wrapped in jute.

5.5 1 mm (solid) and 13 mm strand wire shall be supplied on wooden
5.6 6.5³, with approx; One kilometre on each reel. The barrel of the
reel shall not have diameter less than 45 times the overall
reel er of the complete wire. Reel shall be non-returnable,
diamet new wood, properly fixed with heavy wood lagging adeq-
made of onstructed to withstand rough handling. Wood lagging
uately c securely fastened by steel straps. Wooden reels and
shall be all be treated with preservatives.
lagging sh LABELLING

6 MARKING AN marked with manufacturer's name, size of wire,
6.1 A paper label coil in killograms and date of manufacture, shall
weight of the e jute packing, anywhere on the other periphery.
be pasted on th
ation shall be clearly marked on each reel
6.2 The following inform 13 mm strand wire.
of 6.5 mm (solid) and
e in kilometer

i) Length of wir net weight
ii) Gross, tare and
iii) Size of the wire ng
iv) Direction of un-reeli

7 REJECTION

irement of this specification,
7.1 If any wire fails to meet any requ m the same coil and retes-
two new specimens shall be taken fro cond test the entire lot
ted. If any failure occurs in the se
shall be rejected.

11 14

SPECIFICATION P-116: 81

E A R T H R O D

PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY
DESIGN DEPARTMENT (T&G) WAPDA

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PRINTING HISTORY

First edition October,1977

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SPECIFICATION P-116: 81

E A R T H   R O D

0 FOREWORD

0.1 This specification has been prepared by the Design Department of Power Wing, WAPDA.

0.2 This specification is intended for the procurement of material and does not include provision of the contract.

1 SCOPE

1.1 This specification covers earth rods for use in sub-station grounding system.

2 GENERAL

2.1 The earth rods are the mild steel rods which are protected against rusting by a thick exterior of copper, permanently molten welded or electrolytically deposited to a high strength steel core which provides rigidity for easy driving without bending.

2.2. The earth rod should have a cone point and chamfered head for ease in driving in the soil.

3 MATERIAL

3.1 The steel used in the manufacture of earth rods shall have the following characteristics:

Tensile strength	41-56 kg/mm^2
Min. yield point	25 kg/mm^2
Min. elongation	20% in 200mm gauge length

4 CONSTRUCTIONAL REQUIREMENTS

4.1 The earth rod shall be manufactured from mild steel of the characteristics as defined in clause 3.1.

4.2 After manufacturing the steel rods, a thick surface of copper shall be permanently molten welded or electrolytically deposited uniformly.

4.3 The thickness of the copper surface shall not be less than 0.33 millimeter.

4.4 The earth rod shall have a cone point and chamfered head as per drawing No. PDW/DF-268 (Rev.I).

4.5 The covers and edges of earth rod shall be rounded off and there shall be no cracks or burrs or sharp projections.

4.6 The dimensions of the earth rod shall be according to the Drawing No. PDW/DF-268 (Rev. I).

5 TESTS

5.1 The following tests shall be carried out on the earth rod:

1) Visual Examination
2) Verification of Dimensions
3) Bending Test
4) Tensile Test
5) Adhe... ce Test

6 TESTS METHODS

6.1 Visual Examination

Individual rods shall be visually examined for the defects given below:

T A B L E

Sr. No.	Examination	Defects
1.	Construction	Not of shape shown in drawing. Not of correct material. Any crack on the material.
2.	Finish	Copper thickness not proper, presence of burrs, black or base spots, and projections which will interfere with the proper use of the article. Corner edges not rounded.
3.	Marking	Missing, not legible, incomplete or not permanent.

6.2 Verification of Dimensions

The dimensions shall conform to the drawing attached.

6.3 Bending Test

6.3.1 The earth rod shall be capable of withstanding the cold-bend test as specified in the following clause 6.3.2

with out any evidence of pits, cracking, or separation of copper from steel on the surface of the bent portion.

6.3.2 The earth rod shall be subjected to a cold bending test at ambient temperature. The rod shall be held in a suitable rigid clamp or vice and the free end bent by applying a force perpendicular to the rod at a distance of 40 times rod diameter from the clamping device. The normal force shall be applied until a permanent angular bent of 30 degrees is achieved by the rod. The rod shall meet the requirements of 6.3.1.

6.4 Tensile Test

6.4.1 The steel shall be tested for tensile strength as per ISO/R-82-1947.

6.5 Adherence Test

6.5.1 The earth rod shall be subjected to adherence test to determine the bondage between copper and steel surfaces. A half meter length of rod with one and cut to a 45 degree point. This end shall be driven between two steel clamping jaws of a vice set at one millimeter less than the diameter of the rod so as to shear off sufficient metal to expose the bond between the jacket and steel core. There shall be no evidence of any separation.

7 SAMPLE, ACCEPTANCE AND REJECTION

7.1 The earth rod shall be divided into lots containing upto 500 units each. A sample of 50 rods shall be drawn at random from each lot.

7.2 The selected samples shall be subjected to visual examination and verification of dimensions. If the number of defective units is four the lot shall be accepted, if the number of defective units is more than five the lot shall be rejected. If the number of defective units is five, another sample of 50 units shall be selected at random and subjected to tests. If the number of defective units is again five or more, the lot shall be rejected. If the number of defective units is four or less the lot shall be accepted.

7.3 Three random samples of all items selected from lot of 500 each rods shall be subjected to tensile, bending and adherence tests.

7.4 If one rod from any group of three units selected as per clause 7.3 fails to meet the requirement, another group of three rods shall be selected at random. If any units in the second group fails the test, the lot shall be rejected.

8 MARKING

8.1 Individual earth rod shall be punched with 'WAPDA-ED' and manufacturer's name or trade mark. The size of lettering shall be at least 5 millimeter.

8.2 The marking of earth rod shall be located within 300 millimeter of the top of the rod.

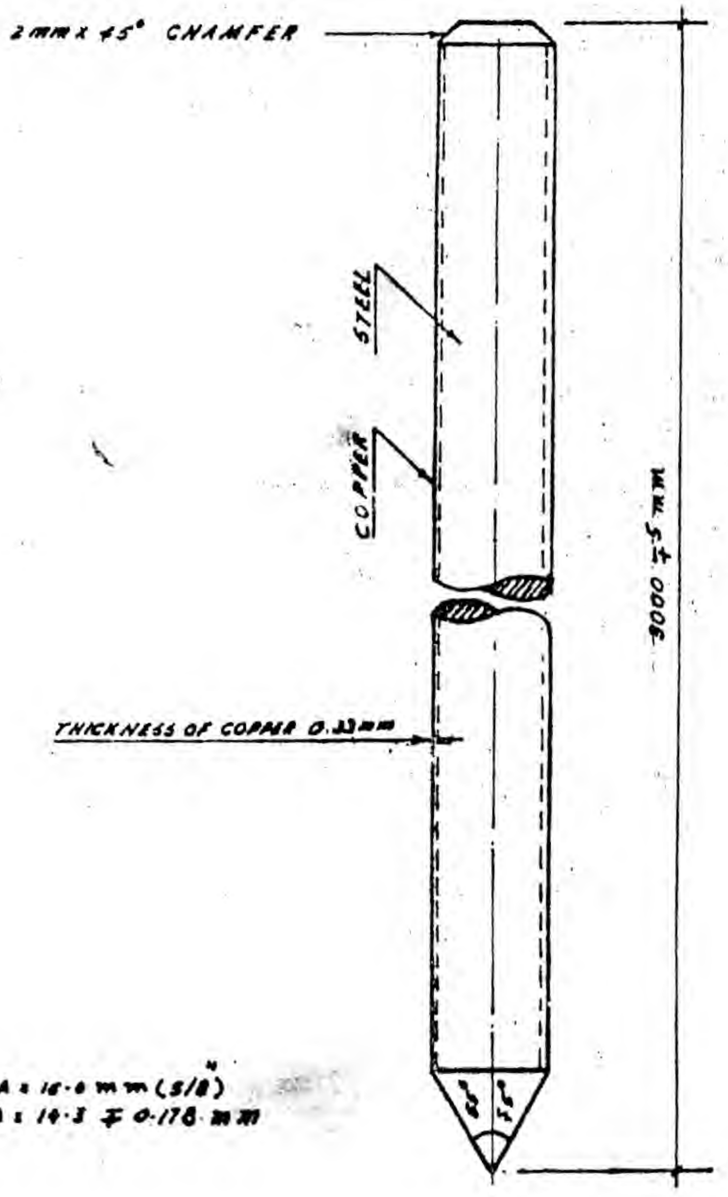
9 PACKING

9.1 The earth rods shall be bundled and banded in group of five to seven. The bundling shall be at three locations with galvanized steel wire or steel binding strap. The bundles then be packed in wooden crates, capable of withstanding the rigours of transportation and handling.

Enclosure: Drawing No. PDW/DF-268 (Rev-I)

PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY

DWG. No. PDW/DF-268



NOMINAL DIA = 16.0 mm (5/8")
ACTUAL DIA = 14.3 ∓ 0.178 mm

NO	DATE	REVISIONS	BY
1	2-3-81	DIAMETER CHANGED FROM 16.0 mm TO 14.3 mm & THICKNESS REVISED	[signature]

EARTH ROD

DWN. [signature]	[signature] A.E.	DESIGN DEPARTMENT
TCD. AZHAR IQBAL	[signature] A.D.	DATE: 15-10-77
CKD. [signature]	APPRD. [signature] DIR.	SCALE. ✓