HEAT SHRINKABLE PVC SLEEVE FOR HIGH VOLTAGE BUSBARS AND CONNECTIONS

1. General :

Heat shrinkable PVC sleeves are used in switchgear panel products to provide insulation for high voltage round / rectangular / square busbars and connections in straight and bent connections. These sleeves are given a special treatment during the manufacturing process resulting in an in-built property of shrinking which is released at elevated temperatures. These sleeves are of fire retardant, self extinguishing grade.

2.0 Size and selections

2.1 The sleeve size is specified in terms of " Laid Flat " (L/F) dimension i.e, the sleeve width when laid flat. Available L/F sizes in mm are 240, 190, 165, 150, 140, 128, 102, 82, 74, 64, 58, 51, 43, 38, 24, 18 & 15.

2.2 Desired lengths may be ordered, however standard rolls are available in lengths of 50 metres.

2.3 The thickness of sleeve is 0.4+ 0.03 mm before heat shrinking. The achieved thickness after heat shrinking depends upon the sleeve L/F & busbar or connection size.

2.4 Unrestricted shrinkage of the sleeve is :

- in lengthwise direction : 10 %
- in width-wise direction : 40 %

2.5 The recommended sleeve sizes to be used are given in Table 1 below :

TABLE 1

S.No	Heat shrinkable PVC sleeve size		Cu/Al Busbar or connection (mm)
	L/F + 0.5 (mm)	Sleeve thickness (mm)	
1.	240	0.4	12 x 200, 10 x 200
2.	190	0.4	12 x 150, 10 x 150
3.	165	0.4	12 x 125, 10 x 125
4.	150	0.4	12 x 100, 20 x 100
5.	128	0.4	12 x 75*, 10 x 75 *
6.	102	0.4	25 x 50, 12 x 75, 10 x 75
7.	82	0.4	12 x 50, 10 x 50
8.	74	0.4	6 x 50
9.	51	0.4	27 dia
10.	38	0.4	5 x 20
11.	24	0.4	3 x 16, 10 dia

(* Preferred for bent connections)

2.6 Single / Double layer of sleeves :

Generally a single layer of 0.4 mm tk sleeve is sufficient for voltages upto 12 kV system. However in special constructions where busbars / connections are in close proximity or for higher system voltages (upto 24 kV), two layers of sleeves are recommended. See Table 2 for such recommendations :

TABLE - 2

S.No.	APPLICATION FOR PRODUCT TYPE		NO OF SLEEVE LAYERS FOR BUSBARS AND CONNECTIONS
	TYPE	RATED VOLTAGE (KV rms)	
1.	VM12	12	SINGLE LAYER
2.	VM12	12	SINGLE LAYER
3.	VMN12	12	SINGLE LAYER
4.	VM24	24	DOUBLE LAYER

3. Material properties :

The sleeves shall have the following properties :

PROPERTY	UNIT	TEST METHOD	VALUE
PHYSICAL			
1. Material identification	-	-	PVC
2. Specific gravity	-	BS2782-1970 (Method 509A)	0.8 to 0.9
3. Water absorption	%	BS2782-1970 (Method 502G)	0.35max
FLAMMABILITY :			
4. Flame class	class	UL94	Vo
MECHANICAL :			
5. Tensile strength	Kg/Sq cm	BS2782-1970 (Method 320 E)	>400
6. Ultimate Elongation	%	- do -	>or=300
THERMAL :			
7. Continuous operating Temperature	Deg C	-	105
8. Surface resistivity	Ohm	BS2782-1970	$>10^{12}$
ELECTRICAL :			
9. Electrical strength (Proof and Breakdown) in air at various temperature	kV/thickness of sleeve after shrinkage	BS2782-1970 (Method 201G)	As per table 3

TABLE - 3

Temperature deg C	Single Sleeve		Double sleeve	
	One minute withstand voltage (kV)	Breakdown voltage (kV)	One-minute withstand voltage (kV)	Breakdown voltage (kV)
30	13	18	28	34
90	9	11	21	26
115	7	8.5	19	23

4. Colour of sleeve

Sleeve are generally black in colour, however red,yellow,blue and green coloured sleeves can also be ordered.

At continuous elevated temperature of more than 105 degree C fading of colours other then black may be observed.

5. Method of sleeving :

Heat shrinkable PVC is supplied in its unshrinkable laid flat state (creased type). When heated to temperature of 120 deg C, the sleeve will shrink to a predetermined size or confirm to the size of busbar / connection to be covered. Following are the recommended cares / steps during the sleeving process :

i) All burrs on the edges of the busbars / connections should be removed to avoid damage to the sleeve.

ii) Protective capping of the conductor end :

Sleeve of length 60 mm approx shall be slipped over the conductor end for about 30 mm. Subject the sleeved conductor end to the shrink temperature of 120 deg C for the sleeve tp shrink and form a protective cap over the conductor end. allowed the conductor to cool. The protective cap now formed prevents the scartching of internal surface of sleeve while insertion over the conductor by free burrs and / or sharp edge of the conductor. This cap can be removed by cutting after the shrinking procedure is over.

iii) Slipping of sleeve over the conductor :

- Lubricate bend busbar / connection by applying a thin film of silicon grease (with a melting temperature above shrink temperature). Straight conductors do not need to be lubricated.

- Slip the specified length of the sleeve over the conductor from the "capped end" and pull it to cover the desired length of the conductor to be sleeved. The cap can now be removed by cutting. It may be noted here that bends -specially with "U" or "Z" shapped conductors may cause a certain longitudinal shrinkage of the conductor upto its terminals, apply the sleeve in folds evenly over the total length. For conductors with several bends it is recommended to determine the exact length by a trial run.

iv) Shrink Procedure :

- For heat shrinking process the use of an oven with air circulation is recommended with a minimum temperature of 120 deg C + 10 deg C.

- Place the conductor with loosely covered sleeve in the pre-warmed oven. Suspend or support the conductor at the terminals to allow un-restricted recovery. Care shall be taken that the sleeve is not touching oven walls or floor.

The recommended shrink temperature is 120 deg C + 10 deg C and shrink time of 20 minutes + or - 5 minutes for smooth sleeving. The bend connections may require slightly more shrink time. The shrink temperature should not exceed 130 ^{o}C
Minimum conductor temperature should be 100 deg C when leaving the oven.

v) Shrink procedure for straight conductor :
General procedure as outlined in para 5 iv) is applicable.

vi) Shrink procedure for bend conductor :
Sleeve of length 125 mm is cut and slipped over the bend conductor and is positioned at hte bend to cover both arms of the bend uniformly. The conductor is then subjected to shrink procedure and the sleeve should cover the bend without undulations leaving no air cavity. Allow the conductor to cool to the room temperature. Both arms of this conductor now shall be sleeved individually by slipping sleeves of appropriate length from each capped end till the preshrunk bend portion is completely overlapped resulting, after shrinkage, in the encapsulation of the conductor with a smooth sleeving over the conductor.

vii) Shrink procedure for double sleeving :
The first layer of the sleeve is shrunk over the conductor as per general procedure outlined above and cooled down to the room temperature. For " Double sleeving " the same procedure is repeated after inserting the cool pre sleeved conductor again in fresh unshrunk sleeve resulting in double ayered sleeved conductor.

viii) Finishing :
Allow the insulated conductor to cool to room temperature. Trim the ends to the required distances. No tearing of ends shall be observed after shrinking. The shrunk sleeve shall give smooth surface finish without undulations. In case of discrepency, the job must be re-heated for a further appropriate period.

ix) Handling and storage :
The sleeved conductor after finishing must be wrapped in polythene sheets / bags and stacked over wooden battons. Contact with sharp objects must be avoided.

x) Shipment :-
Sleeved busbars / connections when shipped loose shall be packed as per SG 14602 .

6. Testing and Quality checks :

For heat shrinkable PVC sleeve :

6.1 Dimensional check :
The laid flat (L/F) and thickness of the sleeve shall be as per P.O. items.

6.2 Tests for properties :
The important properties water absorption, flammabitiy class, Dielectric strength and material identification shall be checked and values shall be as per para 3.

For sleeved conductors :

6.3 Visual checks :
The sleeved conductor shall have a smooth surface finish without any undulation or air pockets.

6.4 Two nos samples fromeach lot of straight / bend and single / double sleeved conductors shall be subjected to one minute withstand voltage test in air at room temperature ,to values mentioed in para 3. There shall be no breakdown or puncture across the sleeve material.

7. Acceptance criterion for sleeves :

a) Supplier shall send certificate of tests conducted for requirements mentioned in para 6.1 and 6.2 with each lot of supply.

b) Tests at BHEL : Dimensional checks and tests for properties mentioned in Para 6.1 and 6.2 shall be conducted on a sample length of 400 mm cut from the main roll from cosignmant.

8. Supply condition :

The PVC sleeves shall be supplied in rolls over hard cardboard tubes and these rolls must be covered with polythene sheets and kept in cardboard containers.

Source of supply, expiry dte, storage conditions, sleeve dimensions and BHEL PO. Nos shall be clearly marked on the hard cardboard tube which shall be visible without unrolling the sleeve. The same markings shall also be put on outside of cardboard containers.