GOVERNMENT OF ZAMBIA

STATUTORY INSTRUMENT NO. 59 OF 2013

The Standards Act
(Laws, Volume 23, Cap 416)

The Standards (Compulsory Standards) (Declaration) Order, 2013

IN EXERCISE of the powers contained in section *seven* of the Standards Act, the following Order is hereby made:

Title

1. This Order may be cited as the Standards (Compulsory Standards) (Declaration) Order, 2013.

Declaration of compulsory standards

2. The standards set out in the First Schedule are declared as compulsory standards.

Application of standards

3. The standards set out in the First Schedule shall apply to the respective commodities listed in the Second Schedule.

FIRST SCHEDULE
(Paragraph 2)

COMPULSORY STANDARDS

ZAMBIA BUREAU OF STANDARDS

Zambian Standard 688
Part I-General

ELECTRIC CABLES WITH EXTRUDED SOLID DI-ELECTRIC INSULATION FOR FIXED INSTALLATIONS (300/500 V, 600/1000 TO 1 900/3 300 V) – SPECIFICATION

1. SCOPE

1.1 This Part of the Zambian standard specifies the requirements for packing and marking, and informative Annexes for single-core and multicore extruded solid di-electric insulated cables of rated operating voltage (U_0 / U) in the range 300/500 V, 600/1 000 V and 1 900/3 300 V, for use in fixed installations, as covered by Zambian standard ZS 688-2 to ZS 688-6.

1.2 Specific requirements are given for the types cables in common use which are—
(a) single-core and multicore cables, armoured and unarmoured;
(b) multicore flat cables with and without an earth continuity conductor;

Copies of this Statutory Instrument can be obtained from the Government Printer, P.O. Box 30136, 10101, Lusaka, Price K26.00 each

(c) multicore round cables with aluminium / PVC laminate and an earth continuity conductor;

(d) cables with concentric conductors;

(e) cables with split concentric neutral and earth conductors;

(f) panel/cubicle cables, excluding flexible cables and cords; and

(g) insulated earth conductors.

1.3 This specification also covers cables that reduce the overall risk associated with fires.

2. TERMS AND DEFINITIONS

For the purposes of this Part of ZS 688, the following definitions shall apply:

2.1 Acceptable

Acceptable to the authority administering this standard or to the parties concluding the purchase contract, as relevant.

2.2 Armour

A layer of wires applied to a cable to provide mechanical protection or earth continuity, or both.

2.3 Bedding

A layer of extruded compound applied to a cable to form a circular base beneath the armour in order to prevent damage to the insulation by the armour or to form a base for the sheath.

2.4 Cable

One or more cores with or without an overall protective covering.

2.5 Concentric conductor

A conductor in the form of a single layer of wires that are laid helically around one or more central cores.

2.6 Core

A single insulated conductor without protective covering.

2.7 Di-electric

The covering of a conductor that is intended to insulate the conductor electrically.

2.8 Di-electric of lay

The lateral direction of inclination to the axis (either left hand or right hand) of the receding helix formed by a wire or a core in a cable.

2.9 Filler

The material that fills the interstices of the cores of a multicore cable.

2.10 Fire retardant cable

A cable modified in construction or composition, or both, and contains properties which are less affected by fire.

2.11 Flame propagation

Spreading a flame along a cable or cables under defined fire conditions.

2.12 Halogen emission

The release of halogen gas from cable material under defined fire conditions.

2.13 Lay ratio

The ratio of the axial length of a complete turn of the helix formed by an individual core in a multicore cable to the pitch circle diameter of the helix formed by the same core.

2.14 Operating voltage is the voltage designation of cables U_o/U (U_m) as follows:

U_o- is the rated power frequency voltage between conductor and earth for which the cable is designed;

U – is the rated power frequency voltage between conductors for which the cables is designed; and

U_m – is the maximum value of the highest system voltage for which the equipment may be used.

2.15 Routine test

A test conducted on the manufacturer's works on all cable lengths during manufacture after the manufacture of the cables.

2.16 Sample test

A test conducted on a regular basis on the manufacturer's works or on representative samples taken by the manufacturer, or as requested by the purchaser at the time of enquiry or order.

2.17 Sheath

An extruded protective covering applied to a cable.

2.18 Turned core

A core found in a shaped conductor cable that has, at any point along the length of the cable, deviated from its intended angular orientation.

2.19 Type test

A test conducted before a type of cable covered by this standard is supplied on a general commercial basis, in order to demonstrate that the cable has the necessary performance characteristics for the intended application. The test, when successfully completed, need not be repeated unless changes are made in the cable materials or design that might change the performance characteristics of the cable.

ABBREVIATIONS

2.20 ECC

Earth Continuity Conductor

3 PACKING AND MARKING

3.1 *Packing*

Cables shall be packed on drum, reels or in coils.

3.1.1 Drums and reels

The moisture content of the wood of a wooden drum or reel shall not exceed 20 %. Where wooden drums or reels are required to be resistant to biological attack, the wood shall be impregnated (by pressure or in a hot or cold open tank) in accordance with ZS 771 with a class C preservative or with chromated copper arsenate.

3.1.2 Cable ends

Each end of the cable shall, before being secured to the drum or reel, be sealed by an acceptable method. The outer end shall be secured to the drum or reel, and the inner end shall be protected in an acceptable manner against mechanical damage.

3.2 *Marking*

3.2.1 Marking of cables

The information listed in the following paragraphs shall appear in legible and indelible marking on the external surface of each finished cable:

(a) the manufacturer's name, trade name or trade mark;

(b) the operating voltage (U) for which the cable has been designed, given in volts or kilovolts (e.g. 500 V, 1 000 V or 3.3 kV), in two lines on opposite sides of the cable where the cable overall diameter exceed 15 mm;

(c) when applicable, information on the special properties of the cables in accordance with column 3 of table 1 (Optional additional marking can be done in accordance with column 2); and

(d) where required, a marking that indicates the cross-sectional area and the number of cores.

The letters and numerals shall be upright characters of maximum height of 13 mm and minimum height of 3 mm. In the case of cables that have an overall diameter of less than 6 mm, the height area of the characters may be less than 3 mm provided that the legend is acceptably legible. The gap between the end of one legend and the beginning of the next shall not exceed 150 mm.

Table 1—MARKING OF CABLES

Property	*Marking*	*Colour of strips*
General purpose	—	No stripe
Reduced smoke emission	LS	No stripe
Reduced halogen emission	LH	No stripe
No halogen emission	NH	No stripe
Reduced flame propagation	FR	Red
Reduced halogen emission and reduced propagation	LHFR	Blue
No halogen, reduced smoke emission and reduced propagation	NHLSER	White

3.2.2 Marking of coils

Each coil package shall bear the following information in legible and indelible marking:

(a) the manufacturer's trade name or trade mark or both;

(b) the rated voltage, the cross-sectional area of phase conductor(s), and the number of cores; and

(c) the length of cable.

3.2.3 Marking of drums or reels

Each drum or reel shall bear the following information in legible and indelible marking:

(a) the information required in 3.2.2;

(b) a brief cable description;

(c) the gross mass;

(d) an identifying serial number;

(e) unless the manufacturer guarantees that the drum or reel may be laid flat without damage to the cable, the words "NOT TO BE LAID FLAT" (in capital letters), or a suitable pictogram;

(f) unless the manufacturer guarantees that the drum or reel may be rolled in either direction without damage to the cable, an arrow or the words "ROLL THIS WAY" (in capital letters, to indicate the direction in which the drum or reel is to be rolled in order to prevent the cable from unwinding); and

(g) if the wood of the drum or reel has been treated, a capital letter "T" of approximate height 50 mm surrounded by a circle of approximate outside diameter 65 mm.

ANNEX A
(Informative)

NOTES TO PURCHASERS

A.1 Before the purchaser orders cables produced to this specification, it is suggested that the following points be considered:

A.1.1 Identification of cores

The identification of cores, particularly in power cables, should preferably be done by colour coding.

Identification by numbers is also acceptable. The neutral must always be black or carry the number -0-, or both. Particular care should be taken to select the correct colours when a three-core or four-core cable intended for use on single-phase circuits is being ordered.

A.1.2 Current rating

The current rating of the cable and the applicable rating factors for a particular installation should be ascertained from the cable manufacturer. This information is also given in ZS 772.

A.1.3 Type of cable

Careful consideration should be given to the type of cable to be used for a particular installation.

Alternatives such as copper or aluminium conductors, conventional PVC insulation and sheathing flame-retardant, low smoke emission, halogen-free cables, armoured or unarmoured cables, should be considered.

A.2 It is recommended that the following requirements be specified in invitations to tender and in each order or contract:

(a) the maximum permissible operating voltage;

(b) the conditions of service of the cable;

(c) the conductor material (copper, tinned copper or aluminium) and the type of conductor;

(d) the type of insulation material;

(e) colour coding or numbering of cores;

(f) the type of bedding material;

(g) whether the cable is to be armoured;

(h) if the cable is to be armoured, the material of the armour wires;

(i) in the case of a cable with steel wire armour, whether an earth continuity conductor (ECC) is required;

(j) the type of material of the sheath;

(k) in the case of a cable with a metallic sheath, whether the metal is to be lead or lead alloy of type (see Annex B of EN 12548:1999);

(l) whether fire retardant properties are required;

(m) in the case of cables packed on wooden drums, whether the wood of the drum is to be resistant to biological attack; and

(n) whether the number of cores and the cross-sectional area are to be indicated on the cable.

A.3 ZS IEC 60332-3 denotes four optional categories, namely A, B, C and D. Current research indicates that cables that satisfy the requirements for Category C, comply with the flame propagation requirements for steel wire armoured cables in accordance with both national and international standards.

ANNEX B
(Informative)

QUALITY EVALUATION OF EXTRUDED SOLID DI-ELECTRIC INSULATED CABLES

When a purchaser requires ongoing verification of the quality of extruded solid di-electric cables, it is suggested that, the purchaser should, instead of concentrating solely on evaluation of the final product, also direct attention to the manufacturer's quality system and consider Zambian condition ZS 150 9001 which makes provision for an integrated quality system.

ANNEX C
(Informative)

INSTALLATION OF EXTRUDED SOLID DI-ELECTRIC INSULATED CABLES

C.1 Information on the installation of extruded solid dielectric insulated cables

Information on the installation of extruded solid dielectric insulated cables is given in ZS 777-2 and ZS 777-8.

C.2 Minimum installation bending radii

Although cables that comply with this specification are designed to have a certain flexibility, it is necessary that bending (and any subsequent straightening) be done slowly and carefully. The radii of bending given in table C.1 (measured on the inside of the bent cable) represent recommended minimum values and should be exceeded whenever possible.

Table C.1—RECOMMENDED MINIMUM INSTALLATION BENDING RADII

Construction of cable	*Cable diameter D, mm*		*Minimum installation*
	Exceeding	*Not exceeding*	*bending radius*
Insulated only	—	10	3 D
Insulated only	10	25	4D
Insulated only	25	40	6 D
Insulated only	40	—	8 D
Sheathed only	—	—	8D
Armoured	—	—	10 D
Lead sheathed	—	—	15 D

C.3 Voltage test for cables after installation

After installation, the cable may, if so required, be subjected to the appropriate test voltage given in table C.2. The test voltage (either ac or dc) should be applied between conductors and between each conductor and the metallic protection or earthed surroundings of the cable, as appropriate. it should be increased to the full appropriate value, and maintained at this value for 15 min.

Table C.2—Test Voltages after Installation

Cable operating voltage V	*Where test voltage is to be applied*	*Test voltage V*	
		ac (rms)-50Hz	de
300 / 500	Between conductors or conductors and earth	1 000	1 500
600 / 1 000	Between conductors or Conductors and earth	2 000	3 000
1 900 3 300	Between conductors	6 000	9 000
	Between conductors and earth	3 500	5 000

PART 2—WIRING CABLES

ELECTRIC CABLES WITH EXTRUDED SOLID II-ELECTRIC INSULATION FOR FIXED INSTALLATIONS (300/500 V, 600/1000 V AND 1 900/3 300 V) -SPECIFICATION

1 SCOPE

1.1 This Part of the Zambian Standard specifies the requirements for construction, materials, dimensions and electric properties of unarmoured single-core and multicore extruded solid dielectric insulated cables with rated operating voltages (U_o /U) of 300/500 V and 600/1 000 V and a conductor cross-sectional area of 16 mm^2 for use in fixed installations.

1.2 Specific types of cables covered by this Part are the following:

(a) insulated wires (600/1 000 V);

(b) multicore flat and circular sheathed cables (300/500 V);

(c) single-core unsheathed panel/cubicle cables (300/500 V); and

(d) multicore round cables with aluminium/PVC laminate and an earth continuity conductor (300/500 V).

2 NORMATIVE REFERENCES

In this standard, reference has been made to the following standards:

ZS 756-1 Materials of insulated electric cables and flexible cords – Part 1: Conductors;

ZS 756-2 Materials of insulated electric cables and flexible cords – Part 2: Polyvinyl chloride (PVC);

ZS 688-1 Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) – Part 1: General;

ZS 772 The wiring of premises – Part 1: Low-voltage installations;

ZS IEC 60811-1-1, Common test methods for insulating and sheathing materials of electric cables – Part 1: Methods for general application – Section 1: Measurement of thickness and overall dimensions – Tests for determining the mechanical properties;

ZS 764 Alternating current spark test on electric cables and cords;

ZS 765 Dielectric resistance of electric cables; and

ZS 769-3 Test methods for cross-linked polyethylene (XP).

NOTE

All standards are subject to revision and, since any reference to a standard is treated as a reference to the latest edition of that standard, parties to agreements based on this Part of ZS 688 are encouraged to take steps to ensure the use of the most recent editions of the standards indicated. Information on currently valid national and international standards can be obtained from the Zambia Bureau of Standards.

3 DEFINITIONS

For the purposes of this Part of the Zambian standard ZS 688, the definitions provided in Zambian standard ZS 688-1 shall apply.

4 GENERAL REQUIREMENTS

4.1 Cable Operating Voltage

The maximum permissible operating voltage of a cable shall be either 300/500 V or 600/1 000 V with the (U_m) for the 600/1000V (1.2 kV).

4.2 *Materials and Construction*

4.2.1 Conductors

A conductor shall be of plain or tinned annealed copper, as required, and shall comply with the requirements of ZS 756-1.

4.2.2 Insulation

4.2.2.1 Material

The insulation shall be extruded PVC complying with the requirements for insulation grade PVC of ZS 765-2.

4.2.2.2 Thickness and insulation resistance

4.2.2.2.1 Unless otherwise stated in the relevant specific requirements given in clause 5, the nominal thickness and the insulation resistance of the insulating material shall comply with the requirements given in table 7, as appropriate to the cross-sectional area of the conductor and operating voltage.

4.2.2.2.2 When the thickness of the insulation is determined in accordance with ZS IEC 60811-1-1, the average thickness shall be at least equal to the nominal value, and the minimum thickness at any point may be less than the nominal value, except that the difference shall not exceed 0.1 mm + 10 % of the nominal value.

4.2.2.3 Spark resistance of insulation

All core insulation shall be spark tested using the method given in Zambian standard ZS 764 at an ac rms test voltage of 5 000 V in the case of 300/500 V cables, or at 6 000 V in the case of 600/1 000 V cables, without breakdown of the dielectric. Alternatively a dc test voltage 1.5 times the appropriate ac rms test voltage may be used.

4.2.3 Core identification

4.2.3.1 Identification

Cores shall be identified durably and distinctly by colouring as specified in table 1.

4.2.3.2 Earthing cores

Where an earthing core is not bare it shall be coloured green and yellow, and the combination of the colours shall be such that one colour covers not less than 30 % and not more than 70 % of the surface of the core, and the other covers the remainder of the surface. There shall be no green or yellow coloured core in a two-core cable or in any non-earthing type cable.

NOTE: The combination of green/yellow is reserved exclusively for the identification of the earthing core.

Table 1 – Core Identification

Numbers of phase cores	*Colours (s) of phase cores*	*Colour of neutral core*	*Colour of earthing core (if present and not bare*	*Colour of special purpose core (if present)*
1	Any, except green	—	—	—
1	Red	Black	Green / yellow	Orange
2	Red and yellow	Black	Green / yellow	Orange
3	Red, yellow and blue	Black	Green / yellow	Orange
4 or more	Any ase colour except green and orange with with serial numbers (numerals or words)			

4.2.4 *Assembly of cores*

4.2.4.1 General

The cores of a multicore cable shall be compactly laid up with an acceptable lay and in the correct sequence of their identification colours or numbers.

4.2.4.2 Fillers

Fillers may be applied integrally with the bedding or the sheath, as applicable, and shall be used in the interstices of the cable where necessary to give the completed cable a compact circular cross-section. Filler materials shall be such as to be acceptable for the specific type of cable.

4.2.4.3 Binder

A binder may be applied over the laid-up cores and the material shall be such as to be acceptable for the specific type of cable.

4.2.5 *Sheaths*

4.2.5.1 General

Sheaths shall consist of a continuous extrudate that closely fits but does not adhere to the underlying core or assembled cores. The surface of the extrudate shall have a smooth finish and its profile shall be uniform and appropriate to the type of cable.

4.2.5.2 Material

The sheath shall consist of an extruded layer of PVC of type S1 to S4 of ZS 756-2.

4.2.5.3 Thickness

4.2.5.3.1 Unless otherwise stated in the relevant specific requirements given in paragraph 5, the nominal thickness of the sheath shall be as stated in table 2.

4.2.5.3.2 When the average thickness of the sheath is determined in accordance with ZSIEC 60811-1-1, nominal value provided that the difference does not exceed 0.1 mm + 15 % of the nominal value.

Table 2 —THICKNESS OF SHEATH

Nominal diameter under sheath mm	*Thickness of sheath* mm	
	Unarmoured cable Nominal	*Minimum*
≤10>	1.6	1.26
> 10 ≤ 15	1.8	1.43
> 15 ≤ 20>	1.8	1.43
> 20 ≤ 25	2.0	1.60
> 25 ≤ 30	2.0	1.60
> 30 ≤ 35	2.2	1.77

4.3 Electrical Requirements for Finished Cables

4.3.1 Conductor resistance

The dc resistance of each conductor shall not exceed the appropriate maximum value given in ZS 756-1.

4.3.2 Voltage withstand

When a cable is factory tested in accordance with ZS 769-3, each core of the cable shall withstand, for 10 min without breakdown of the dielectric, a test voltage of the appropriate value given in column 3 or 4 of table 3. Alternatively, the test may be conducted for 5 minutes at a test voltage of the appropriate value stated in column 5 or 6 of table 3.

Table 3 — TEST VOLTAGES

Cables		*Alternating current rms test voltage V*			
Rated voltage V	*Type or cross-sectional area*	*10 minute test*		*5 minute test*	
		Between conductors	*Between any conductor*	*Between conductor and earth*	*Between any conductors and earth*
300/500	Single core cable or panel / cubicle cable	—	1 200	—	1 800
300/500	Multicore cable	1 500	1 500	2 250	2 250
600/1 000	Cables of cross sectional areanot exceeding 16 mm^2	2 000	2 000	3 000	3 000

4.3.3 Di-electric resistance

When a cable is tested in accordance with ZS 765, the insulation resistance of the cable shall be at least equal to the value given in the appropriate columns of tables 5, 6 and 7.

5 SPECIFIC REQUIREMENTS FOR TYPES OF CABLE IN COMMON USE

5.1 Insulated Wire (600/1 000 V)

5.1.1 Construction

The conductor shall be circular stranded, annealed copper complying with the requirements of Zambian standard ZS 756-1, class 2. The insulation shall be coloured as stated in table 1 and shall meet the requirements of PVC type D1 or D2 of ZS 756-2.

5.1.2 Requirements

The thickness and insulation resistance of the PVC insulation shall comply the stipulations of columns 5, 6 and 7 in table 7.

5.2 Multicore Flat and Circular Sheathed Cables (300/500 V)

5.2.1 Construction

Each core of a multicore cable shall consist of a circular solid or stranded annealed copper conductor.

The insulation shall be coloured as stated in table 1 and shall meet the requirements of PVC type D1 or D2 of ZS 756-2.

The cores shall be adjacent in a circular or flat arrangement and shall be sheathed. The sheath shall completely surround the cores, shall be close fitting but shall not adhere to the cores. An uninsulated annealed copper earth continuity conductor, as stated in column 6 of table 5, may be included between the cores.

5.2.2 Requirements

Each cable shall be manufactured in compliance with the relevant requirements given in table 5.

5.3 Single-Core Unsheathed Panel / Cubicle Cables (300/500 V)

5.3.1 Construction

A single-core cable shall consist of a circular solid annealed copper conductor which shall be manufactured in compliance with the requirements of table 6. The insulation shall be coloured as per table 1 and shall meet the requirements of PVC type D1 of ZS 756-2.

5.3.2 Requirements

Each cable shall be manufactured in compliance with the relevant requirements given in table 6.

5.4 Circular Sheathed Multicore Cables With Bare Earth Continuity Conductors and Aluminium / PVC Laminate (300/500v)

5.4.1 Cables shall have 2, 3 or 4 cores, coloured as stated in table 1.

5.4.2 Cables shall have solid or stranded conductors as stated in table 5.

5.4.3 Insulation thickness and insulation resistance shall be manufactured in compliance with columns 2, 3 and 4 of table 7.

5.4.4 Aluminium laminate shall consist of longitudinally applied aluminium tape of minimum thickness 0.1 mm, covered by a sheath.

5.4.5 Earth continuity conductors shall be tinned annealed copper and shall comply with the requirements given in table 5.

5.4.6 Earth continuity conductors for a four-core cable shall be manufactured in compliance with the requirements set out in table 5 for a three-core cable.

5.4.7 The sheath shall consist of extruded PVC that complies with type S1 of ZS 756-2.

5.4.8 The thickness of the sheath shall be at least 0.8 mm and shall be bonded to the aluminium laminate.

6. INSPECTION AND METHODS OF TEST

6.1 General

For convenience, the properties to be tested, the test category, the test methods and the sub-clause giving the requirements are listed in table 4:

Table 4 —LIST OF TESTS TO BE CONDUCTED

Component(s)	*Test Property*	*Test Category*	*Test method given in*	*Requirement subclause*
Conductor	Construction	S	ZS 756-1	4.2.1
PVC Insulation	Physical properties of material	S	ZS 756-2	4.2.2
	Thickness	S	ZS IEC 60811-1-1	4.2.2.2
	Spark test	R	ZS 764	
	Core identification	R, S	Visual examination	4.2.3
	Assembly of cores	R	Visual examination	4.2.4
PVC Sheath	Physical properties of material	S	ZS 756-2	4.2.5.2
	Thickness	S	ZSIEC 60811-1-1	4.2.5.3
Finished cable	Marking	R	Visual examination	4.2 of ZS 688-1
	Conductor resistance	R	ZS 756-1	4.3.1
	Voltage withstand	R	ZS 769-3	4.3.2
	Dielectric resistance	S	ZS 765	4.3.3

NOTE 1: In column 3 of this table, a code letter is given that identifies the tests as suitable for use as routine tests (R) or sample tests (S), but compliance with the requirements of the specification may only be fully determined from the results of tests carried out on samples of completed cable(s), using all the test methods given and a sampling procedure agreed upon. During production control, a manufacturer may use any tests that he deems necessary to ensure compliance with the specification but, in the case of a dispute, only the appropriate standard test methods may be used.

NOTE 2: In the administration of the standardisation mark scheme, the frequency of testing required and the tests to be used are the subject of a separate agreement between the Authority administering this standard and the permit holder.

6.2 Conditions of Test

6.2.1 All tests are to be carried out at ambient temperature and pressure, unless otherwise stated in the test method.

6.2.2 Unless otherwise required in the test method, the frequency of the alternating test voltage used shall be approximately 50 Hz, and the waveform shall be substantially sinusoidal.

Table 5 – REQUIREMENTS FOR MULTICORE SHEATHED CABLES (300/500 V)

Number and cross-sectional area of the conductors mm²	*Nominal radial thickness of Insulation mm*	*Nominal radial thickness of sheath[b] mm*	*Mean overall dimensions mm (flat cables)*		*Earth continuity conductor cross-sectional Area mm², min.*	*Insulation resistance at 23 °C MΩ·km, min.*
			Lower limit	*Upper limit*		
2 x [a]1.0	0.6	0.9	4.0 x 7.2	4.7 x 8.6	1.0[a]	10
2 x [a]1.5	0.7	0.9	4.4 x 8.2	5.4 x 9.6	1.0[a]	10
2 x [a]2.5	0.8	1.0	5.2 x 9.8	6.2 x 11.5	1.5[a]	10
2 x 4.0	0.8	1.1	5.6 x10.5	7.2 x 13.0	1.5[a]	10
2 x 6.0	0.8	1.1	6.4 x 12.5	8.0 x 15.0	2.5[a]	10
2 x 10.0	0.9	1.2	7.8 x 15.5	9.6 x 19.0	4.0	10
2 x 16.0	0.9	1.3	9.0 x 18.0	11.0 x 22.0	6.0	10
3 x [a]1.0	0.6	0.9	4.0 x 9.6	4.7 x 11.0	1.0[a]	10
3 x [a]1.5	0.7	0.9	4.4 10.5	5.4 x 12.5	1.0[a]	10
3 x [a]2.5	0.8	1.0	5.2 12.5	6.2 x 14.5	1.5[a]	10
3 x 4.0	0.8	1.1	5.6 x 14.5	7.4 x 18.0	1.5[a]	10
3 x 6.0	0.8	1.1	6.4 x16.5	8.0 x 20.0	2.5[a]	10
3 x 10.0	0.9	1.2	7.8 x 21.0	9.6 x 25.5	4.0[a]	10

(a) may be a solid or stranded conductor
(b) Sheath thickness for 4 core cables to be same as for 3 core cables

Table 6 – REQUIREMENTS FOR SINGLE CORE UNSHEATHED PANEL/CUBICLE CABLES (300/500 V)[A]

Cross-sectional area conductor mm²	*Diameter of wire in conductor mm*	*Approximate diameter of conductor mm*	*Thickness of insulation mm*		*Conductor resistance at 20 °C Ω/km, max*	*Insulation resistance at 23 °C MΩkm, min.*
			Nominal .	*Min.[b]*		
Calculated	*Nominal*					
0.196	0.5[c]	0.50	0.50	0.40	89.6	10
0.312	0.63[c]	0.63	0.50	0.40	56.4	10
0.396	0.71	0.71	0.55	0.45	44.4	10
0.504	0.8	0.8	0.55	0.45	35.0	10
0.636	0.9	0.9	0.55	0.45	27.6	10
0.785	1.0	1.0	0.55	0.45	22.4	10
0.985	1.12	1.12	0.55	0.45	17.9	10
1.227	1.25	1.25	0.55	0.45	14.3	10
1.539	1.40	1.40	0.55	0.45	11.4	10
2.011	1.60	1.60	0.55	0.45	8.75	10

[a] In terms of the provisions of ZS 778-1, none of these cables may be used for the wiring of premises.
[b] This minimum is the nominal less 0.1 mm.
[c] These cables are suitable for use in pre-wired and nominally sealed subassemblies and in harnesses

Table 7 — THICKNESS AND INSULATION RESISTANCE OF PVC INSULATION OF TYPES D1, D2, D3, D4, D5 AND D6

Cross-sectional area conductor mm²	*Voltage rating*					
	300 / 500 V			*600 / 1 000 V*		
	Thickness of insulation mm		*Insulation resistance[a] at 23 °C MΩ·km, min*	*Thickness of insulation mm*		*Insulation resistance a at 23 °C MΩ·km, min*
	Nominal	*Min.*		*Nominal*	*Min.*	
1.0	0.6	0.44	20	0.8	0.62	25
1.5	0.7	0.53	22	0.8	0.62	24
2.5	0.8	0.62	20	0.8	0.62	20
4.0	0.8	0.62	16	1.0	0.80	19
6.0	0.8	0.62	14	1.0	0.80	17
10.0	0.9	0.71	12	1.0	0.80	14
16.0	0.9	0.71	10	1.0	0.80	11

[a] Based on a minimum volume resistivity of 2,0 x 1011 Ù.m at 23 °C and the nominal thickness of the dielectric.

PART 3—PVC DISTRIBUTION CABLES

ELECTRIC CABLES WITH EXTRUDED SOLID DI-ELECTRIC INSULATION FOR FIXED INSTALLATIONS

(300/500 V TO 1 900/3 300 V) –SPECIFICATION

1 SCOPE

1.1 This Part of the Zambian standard ZS 688 specifies the requirements for construction, materials, dimensions and electric properties of single-core and multicore extruded PVC insulated cables of rated operating voltages (U_0 / U) 600/1 000 V and 1 900/3 300 V, for use in fixed installations.

1.2 Specific types of cables covered by this Part are the following:

(a) single and multicore PVC insulated armoured and unarmoured circular cables with protective covering(s); and

(b) PVC Insulated earth conductors.

2 NORMATIVE REFERENCES

In this standard, reference has been made to the following standards:

ZS EN 12548, Lead and lead alloys – Lead alloy ingots for electric cable sheathing and for sleeves.

ZS 756-1, Materials of insulated electric cables and flexible cords – Part 1: Conductors.

ZS 756-2, Materials of insulated electric cables and flexible cords – Part 2: Polyvinyl chloride (PVC).

ZS 756-6, Materials of insulated electric cables and flexible cords – Part 6: Armour.

ZS IEC 61034-2, Measurement of smoke density of cables burning under defined conditions – Part 2:

Test procedure and requirements.

ZS IEC 60811-1-1, Common test methods for insulating and sheathing materials of electric cables –Part 1: Methods for general application – Section 1: Measurement of thickness and overall dimensions – Tests for determining the mechanical properties.

ZS 764, Alternating current spark test on electric cables and cords.

ZS 765, Dielectric resistance of electric cables

ZS 767, ZS 688-1, Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) – Part 1: General.

ZS 767 Acid gas evolved during combustion of cable materials.

ZS 768 Resistance of cables and cords to flame propagation – Bunched cables and cords.

ZS 769-2, Test methods for impregnated paper-insulated electric cables – Part 2: Tests on metallic sheaths.

ZS 769-3, Test methods for cross-linked polyethylene (XLPE) insulated electric cables – Part 3: Tests on finished cable.

Note

All standards are subject to revision and, since any reference to a standard is deemed to be a reference to the latest edition of that standard, parties to agreements based on this part of ZS 688 are encouraged to take steps to ensure the use of the most recent editions of the standards indicated below. Information on currently valid national and international standards can be obtained from the Zambia Bureau of Standards.

3 DEFINITIONS

For the purposes of this Part of the Zambia Standard ZS 688, the definitions provided in ZS 688-1 shall apply.

4 GENERAL REQUIREMENTS

4.1 Cable Operating Voltage

The maximum permissible operating voltage of a cable shall be 600/1 000 V (1.2kV) and 1 900/3 300 V (3.6kV)

4.2 *Materials and Construction*

4.2.1 Conductors

Conductors shall be manufactured out of plain or tinned annealed copper, or aluminium, as required, and they shall comply with the requirements of ZS 756-1.

4.2.2 *Insulation*

4.2.2.1 Material

The insulation shall be manufactured out of extruded PVC complying with the requirements for insulation grade PVC of ZS 756-2.

4.2.2.2 Thickness and insulation resistance

4.2.2.2.1 The insulation resistance of the insulating material shall meet the requirements stated in table 9, as appropriate to the cross-sectional area of the conductor and operating voltage.

4.2.2.2.2 When the thickness of the insulation is determined in accordance with ZS IEC 60811-1-1, the average thickness shall at least be equal to the nominal value given in table 9, and the minimum thickness at any point may be less than the nominal value provided that the difference does not exceed 0.1 mm + 10 % of the nominal value.

4.2.2.3 Spark testing of insulation

Core insulation be continuously spark tested, using the method given in Zambian standard ZS 764 at the appropriate spark test voltage stated in table 1, without breakdown of the dielectric.

Table 1 – Spark Test Voltage

Cross-sectional area of the conductor mm²		*Alternating current rms test voltage* V[a]	
Above	*Up to and including*	*600/1 000V cables*	*1 900/3 300 V cables*
—	16	6 000	12 000
16	240	10 000	12 000
240	—	12 000	12 000
earth continuity conductor Alternatively, a dc spark test voltage 1,5 times the appropriate ac rms value may be used.			

4.2.3 *Core identification*

4.2.3.1 Identification

Cores shall be identified durably and distinctly by colouring or numbering the insulation as follows:

(a) colour coding: where colour coding is used, the cores shall be insulated in the colours stated in table 2.

(b) numbering: where numbers are used, the marking shall be in a contrasting colour to that of the insulation, and the interval between any two adjacent numbers or words on the same core shall not exceed 75 mm.

Table 2 – Core Colour Coding

Number of phase cores	*Colour(s) of phase cores*	*Colour of neutral core core*	*Colour of earthing (if present)*
1	Red	Black	Green / yellow
2	Red and yellow	Black	Green / yellow
3	Red, yellow and blue	Black	Green / yellow
4 or more	Any base colour except green, with serial numbers (numerals orwords)	Numbered as for phase cores	Green / yellow
Note: Control cables may have uniquely coloured or numbered cores or both.			

4.2.3.2 Colour application

Colour shall be applied—

(a) throughout the thickness of the insulation; or

(b) on the entire surface of the insulation in a durable manner.

4.2.3.3 Earthing cores

An earthing core shall be coloured green and yellow, and the combination of the colours shall be such that one of the colours covers not less than 30 % and not more than 70 % of the surface of the core, and the other covers the remainder of the surface. There shall be no green/yellow coloured core in a two-core cable or in any non-earthing type cable.

Note: The combination of green and yellow is reserved exclusively for the identification of the earthing core.

4.2.4 *Assembly of cores*

4.2.4.1 General

(a) The cores of a multicore cable shall be compactly laid up with an acceptable lay and in the correct sequence of their identification colours or numbers.

(b) There shall be no turned cores in an assembly of shaped cores.

4.2.4.2 Fillers

Fillers may be applied integrally with the bedding or the sheath, as applicable, and shall be used in the interstices of the cable where necessary to give the completed cable a compact circular cross-section. Filler materials shall be acceptable for the specific type of cable.

4.2.4.3 Binder

A binder may be applied over the laid-up cores, and the material shall be acceptable for the specific type of cable.

4.2.4.4 *Concentric conductors*

4.2.4.4.1 A concentric conductor shall consist of a single layer of annealed copper wires, which may be tinned, and are applied helically around the laid-up cores with an acceptable lay.

4.2.4.4.2 The concentric conductor shall be separated from the laid-up cores by a separator consisting of a covering of an acceptable material. The separator shall be extruded and may include a binder. It shall be possible to strip the separator from the cores without tearing the dielectric.

4.2.4.4.3 There shall be no sunken or protruding wires and the space between adjacent wires shall not exceed 4 mm. An equalizing member shall be applied. The equalizing member shall consist of one or more annealed copper tapes or wires applied in contact with the concentric conductors and having a suitably short lay. The nominal cross-sectional area of the equalizing member shall be at least 5 % of the area of the concentric conductor to which it is applied and shall be regarded as part of the conducting area.

4.2.4.5 *Cross-sectional area of concentric conductors*

4.2.4.5.1 The nominal cross-sectional area of a concentric earth continuity conductor (ECC) shall conform to the appropriate value given in table 3.

4.2.4.4.2 The nominal cross-sectional area of a concentric neutral conductor shall—

(a) in the case of single-core cables, be at least equal to that of the phase conductor; or

(b) in the case of multicore cables, be in accordance with table 3.

Table 3 ¯Sizes of Concentric ECCS and Neutral Conductors in Multicore Cables

Cross-sectional area of the Phase conductor mm²	*Areas of ECCs and neutral conductors mm²*			
	Copper phase conductors		*Aluminium phase conductors*	
	ECC	*Neutral*	*ECC*	*Neutral*
1.5	1.0	1.5	—	—
2.5	1.5	2.5	—	—
4	2.5	4	—	—
6	4	6	—	—
10	6	10	—	—
16	10	16	6	10
25	16	16	6	10
35	16	16	6	10
50	25	25	16	16
70	35	35	25	25
95	50	50	35	35
120	70	70	35	35
150	70	70	50	50
185	95	95	70	70
240	120	120	70	70
300	150	150	95	95
400	185	185	120	120

4.2.5 *Protective coverings*

4.2.5.1 General

Non-metallic coverings shall consist of a continuous extrudate that closely fits but does not adhere to the underlying core or laid-up cores or armour. The surface of the extrudate shall have a smooth finish and its profile shall be uniform and appropriate to the type of cable.

4.2.5.2 *Lead or lead alloy sheath*

4.2.5.2.1 Material

Where a metallic sheath is required it shall be of lead or of lead alloy of type E (see annex B of EN 12548:1999), as required, and when it is tested in accordance with Zambian standard ZS 769-2, the composition shall be as given in the appropriate columns of table 4. Its malleability shall be such that, when the sheath is tested in accordance with Zambian standard ZS 769-2 (belling of sheath), the sheath does not split or crack when the internal diameter of the expanded section reaches 150 % of the original internal diameter.

4.2.5.2.2 Construction:

(a) a heat barrier shall be applied over the core assembly before the metallic sheath is applied, and shall consist of one of the following:

(i) a layer of tape (cotton, proofed cloth, crêpe paper or compatible synthetic material) applied helically and of total thickness at least 0.3 mm; or

(ii) an undersheath of extruded PVC of nominal thickness at least 1.0 mm.

(b) the metallic sheath shall be in the form of a continuous tube that is impervious to moisture, reasonably close fitting and free from defects.

Table 4 ¯Composition of Metallic Sheath

Element	*Content%*			
	Type of material			
	*Lead alloy E**		*Lead*	
	Min.	*Max.*	*Min.*	*Max.*
Antimony	0.15	0.25	—	0.20
Tin	0.35	0.45	—	0.10
Copper	—	0.06	—	0.06
Bismuth	—	0.05	—	0.05
Tellurium	—	0.005	—	0.010
Silver	—	0.005	—	0.010
Zinc	—	0.002	—	0.002
Total other elements+	—	0.01	—	0.01
Lead	Remainder	Remainder	99.7	—

* Lead alloy E is recommended for installations subject to vibration.+ All elements other than those specified in the table.

4.2.5.2.3 Thickness

When the thickness of the sheath is determined in accordance with Zambian standard ZS IEC 60811-1-1, it shall be at least equal to the value obtained from the following formula:

$t = 0.033\ D + 0.7$ mm (minimum 1.2 mm)

where -

t is the thickness of sheath, in millimeters; and

D is the calculated diameter over the core or over the laid-up and filled cores, in millimeters.

NOTE: Round off the calculated values of the thickness *t* to the nearest 0.1 mm.

4.2.5.3 *Bedding of armoured cable*

4.2.5.3.1 Material

Bedding shall consist of a smooth surfaced circular layer of PVC, which shall be either type B or type B1 of Zambian standard ZS 756-2. The bedding shall not adhere to the underlying cores or binder.

4.2.5.3.2 Thickness

(a) the nominal and minimum thickness of the bedding shall be as stated in columns 2 and 3 of table 10 or 11; and

(b) when the average thickness of the bedding is determined in accordance with Zambian Sandard ZS IEC 60811-1-1, it shall be at least equal to the nominal value, and the minimum thickness at any point may be less than the nominal value provided that the difference does not exceed 0.1 mm + 15 % of the nominal value.

4.2.5.4 Armour

When so required, the cable shall be armoured, and the armouring shall meet the following requirements:

(a) material: armour shall consist of round wire of galvanized steel or aluminium, as required, and shall comply with Zambian standard ZS 756-6.

(b) armouring: the nominal diameter of armour wire shall be as given in table 10 or 11, as relevant. Armour wire shall be applied with an acceptable lay, without any appreciable space between adjacent wires, and there shall be no crossed, riding or protruding wire. Joints in the wire shall be made to an acceptable standard of workmanship without sharp edges or protruding points, and multiple joints shall be acceptably staggered.

(c) type of armour wire:

(i) for single-core cables, the armour shall be of non-magnetic wire; and

(ii) for multicore cables the armour shall be of galvanized steel wire, except as allowed in paragraph *(d)*.

(d) earth continuity conductor: when an improved conductivity in the earth continuity circuit of steel wire armoured multicore cables is required, an appropriate number of steel armour wires may be replaced by tinned hard-drawn copper wires of the same nominal diameter. The copper wires shall comply with the relevant requirements of Zambian Standard ZS 756-1.

The following requirements shall apply:

(i) the copper wires shall be of diameter equal to that of the armour, and of number as stated in table 5, appropriate to the cross-sectional area of the conductor; and

(ii) the copper wires shall be grouped together and shall not be distributed amongst the armour wires. Where eight or more armour wires are replaced by copper wires, the copper wires shall be arranged in two diametrically opposed groups to allow for a more even distribution of the clamping forces when a mechanical gland is used to terminate the cable.

Table 5 – Earth Continuity Conductor in Wire Armour

Nominal diameter of armour wire mm	*Cross-sectional area of the earth conductor* mm^2														
	1.0	1.5	2.5	4	6	10	16	25	35	50	70	95	120	150	185
	Number of earth continuity conductor wires														
0.9	2	3	4	7	10	17	26	41	57	—	—	—	—	—	—
1.25	2	2	3	4	5	9	14	21	30	40	57	—	—	—	—
1.6	2	2	2	2	3	6	9	13	18	25	35	49	61	76	95
2.0	—	—	—	—	—	—	—	9	12	16	23	31	39	49	61
2.5	—	—	—	—	—	—	—	—	8	10	15	20	25	31	39
3.15	—	—	—	—	—	—	—	—	—	—	9	13	16	20	25
Material	*Cross-sectional area of the Phase conductor* mm^2														
Copper	1.5	2.5	4	6	10	16	25 35	50	70	95	120 150	185	240	300	400
Aluminium	—	—	—	—	16 25 35	—	50	70	95 120	150	185 240	300	400	—	—

4.2.5.5 *PVC Outer Sheath*

4.2.5.5.1 Material

The sheath shall consist of an extruded layer of PVC, which shall be type S2 of Zambian standard ZS 756-2.

4.2.5.5.2 Thickness

(a) the nominal thickness of the sheath shall be as stated in table 6; and

(b) when the average thickness of the sheath is determined in accordance with Zambian standard ZS IEC 60811-1-1, it shall be at least equal to the nominal value, and the minimum thickness at any point may be less than the nominal value provided that the difference does not exceed:

(i) 0.1 mm + 15 % of the nominal value in the case of an unarmoured cable; or

(ii) 0.2 mm + 20 % of the nominal value in the case of an armoured cable

Table 6 – THICKNESS OF OUTER SHEATH

Nominal diameter under sheat mm		*Thickness of sheath mm*					
		Unarmoured cable		*Armoured cable*			
				Without lead sheath		*With lead sheath*	
		Nominal	*Min.*	*Nominal*	*Min.*	*Nominal*	*Min.*
	≤ 10	1.6	1.26	1.4	0.92	1.6	1.08
> 10	≤ 15	1.8	1.43	1.5	1.00	1.6	1.08
> 15	≤ 20	1.8	1.43	1.6	1.08	1.6	1.08
> 20	≤ 25	2.0	1.60	1.7	1.16	1.8	1.24
> 25	≤ 30	2.0	1.60	1.8	1.24	2.0	1.40
> 30	≤ 35	2.2	1.77	2.0	1.40	2.2	1.56
> 35	≤ 40	2.2	1.77	2.2	1.56	2.4	1.72
> 40	≤ 45	2.4	1.94	2.4	1.72	2.6	1.88
> 45	≤ 50	2.6	2.11	2.4	1.72	2.8	2.04
> 50	≤ 55	2.8	2.28	2.6	1.88	3.0	2.20
> 55	≤ 60	3.0	2.45	2.8	2.04	3.0	2.20
	> 60	3.4	2.79	3.0	2.20	3.0	2.20

4.3 Electrical Requirements for Finished Cables

4.3.1 Conductor resistance

The dc resistance of each conductor shall not exceed the appropriate maximum value given in

Zambian standard ZS 756-1

4.3.2 Voltage withstand

When a cable is factory tested in accordance with Zambian standard ZS 769-3, each core of the cable shall withstand, for 10 minutes without breakdown of the dielectric, a test voltage of the appropriate value given in column 3 or 4 of table 7. Alternatively, the test may be conducted for 5 minutes at a test voltage of the appropriate value stated in column 5 or 6 of the table.

Table 7 – TEST VOLTAGES

Cables		*Alternating current rms test voltage V at 50Hz*			
Rated voltage V	*Type or cross-sectional area*	*10 minute test*		*5 minute test*	
		Between conductors	*Between any conductor and earth*	*Between conductors*	*Between any conductor and earth*
600 / 1 000	Cables of cross sectional areanot exceeding 16 mm^2	2 000	2 000	3 000	3 000
600 / 1 000	Cables of cross sectional area 25 mm^2 and above	3 000	3 000	4 500	4 500
1 900 / 3 300	Cables of all sizes	6 700	3 900	10 000	5 800

4.3.3 Di-electric resistance

When a cable is tested in accordance with Zambian Standard ZS 765, the insulation resistance of the cable shall be at least equal to the value given in the appropriate columns of table 9.

4.4 *Additional Requirements for Fire Retardant Cable*

4.4.1 Reduced flame propagation

When a cable that is required to have reduced flame propagation properties is tested in accordance with Zambian Standard ZS 768, the height of the charred or affected portion above the bottom edge of the burner shall not exceed 2.5 m (see also B.3 of annex B of ZS 688-1).

4.4.2 Reduced smoke emission

When a cable that is required to have reduced smoke emission properties is tested in accordance with Zambian Standard ZS IEC 61034-2, the light transmittance shall exceed the following values throughout the test:

Number of specimens of cable tested	*Light transmittance*
4	50 %
3	60 %
2	60 %
1	70 %

4.4.3 Reduced halogen emission

When a cable that is required to have reduced halogen emission properties is tested in accordance with Zambian standard ZS 767, the evolution of halogen gas from the bedding and sheathing obtained from the finished cable shall not exceed 150 mg/g (15 % (*m/m*)).

5 INSPECTION AND METHODS OF TEST

5.1 General

For convenience, the properties to be tested, the test category, the test methods and the sub-clause giving the requirements are listed in table 8:

Table 8 – List of Tests to be Conducted

Component(s)	*Test property*	*Test category*	*Test method given in*	*Requirement subclause*
Conductor	Construction	S	ZS 756-1	4.2.1
PVC Insulation	Physical properties	S	ZS 756-2	4.2.2.1
	Thickness	S	ZS IEC 60811-1-1	4.2.2.2
	Spark test	R	ZS 764	4.2.2.3
	Core identification	R,S	Visual examination	4.2.3
	Assembly of cores	R	Visual examination	4.2.4
PVC Bedding	Physical properties	S	ZS 756-2	4.2.5.3
	Thickness	S	ZS IEC 60811-1-1	4.2.5.3
	Halogen	T	ZS 767	4.4.3
Lead sheath	Construction	S	ZS 769-2	4.2.5.2
	Belling	S	ZS 769-2	4.2.5.2
	Thickness	S	ZS IEC 60811-1-1	4.2.5.2 (c)
Armour	Amour			
	Wire diameter	S	ZS 756-6	4.2.5.4
	Mass of Zinc coating	S	ZS 756-6	
	Adhesion of Zinc coating	S	ZS 756-6	
	Tensile strength	S	ZS 756-6	
	Elongation at break	S	ZS 756-6	
PVC Outer Sheath	Physical properties	S	ZS 756-2	4.2.5.5
	Thickness	S	ZS IEC 60811-1-1	4.2.5.5
	Halogen	T	ZS 767	4.4.3
Finished cable	Marking	R	Visual examination	ZS 688-1: 4.2.1
	Conductor resistance	R	ZS 756-1	4.3.1
	Voltage withstand	R	ZS 769-3	4.3.2
	Dielectric resistance	S	ZS 765	4.3.3
	Fire propagation	T	ZS 768	4.4.1
	Smoke emission	T	ZS IEC 61034-2	4.4.2

Note 1: In column 3 of this table, a code letter is given that identifies the tests as suitable for use as routine tests (R), sample tests (S) or type tests (T), but compliance with the requirements of the specification may only be fully determined from the results of tests carried out on samples of completed cable(s), using all the test methods given and a sampling procedure agreed upon. During production control, a manufacturer may use any tests considered necessary to ensure compliance with the specification but, in the case of a dispute, only the appropriate standard test methods may be used.

Note 2: In the administration of the standardization mark scheme, the frequency of testing required and the tests to be used are the subject of a separate agreement between the Authority administering this standard and the permit holder.

5.2 *Conditions of Test*

5.2.1 All tests are to be carried out at ambient temperature and pressure, unless otherwise stated in the test method.

5.2.2 Unless otherwise required in the test method, the frequency of the alternating test voltage used shall be approximately 50 Hz, and the waveform shall be substantially sinusoidal.

Table 9 – Thickness and Insulation Resistance of PVC Insulation of Types D1, D2, D3, D4, D5 and D6

Cross-sectional area of the conductor	*Voltage rating*					
	600 / 1 000 V			*1 900 / 3 300 V*		
	Thickness of insulation mm		*Insulation resistance[a] at 23 °C*	*Thickness of insulation mm*		*Insulation resistance[a] at 23 °C*
mm²	*Nominal*	*Min.*	*MÙ·km, min.*	*Nominal*	*Min.*	*MÙ·km, min.*
1.0	0.8	0.62	25	—	—	—
1.5	0.8	0.62	24	—	—	—
2.5	0.8	0.62	20	—	—	—
4	1.0	0.80	19	—	—	—
6	1.0	0.80	17	—	—	—
10	1.0	0.80	14	2.2	1.88	25
16	1.0	0.80	11	2.2	1.88	21
25	1.2	0.98	11	2.2	1.88	18
35	1.2	0.98	9	2.2	1.88	16
50	1.4	1.16	9	2.2	1.88	14
70	1.4	1.16	8	2.2	1.88	12
90	1.6	1.34	8	2.2	1.88	10
120	1.6	1.34	7	2.2	1.88	9
150	1.8	1.52	7	2.2	1.88	8
185	2.0	1.70	7	2.2	1.88	8
240	2.2	1.88	7	2.2	1.88	7
280	2.3	1.97	7	2.3	1.97	7
300	2.4	2.06	7	2.4	2.06	7
380	2.5	2.15	6	2.5	2.15	6
400	2.6	2.24	6	2.6	2.24	6
480	2.7	2.33	6	2.7	2.33	6
500	2.8	2.42	6	2.8	2.42	6
600	2.8	2.42	5	2.8	2.42	5
630	2.8	2.42	5	2.8	2.42	5
740	2.8	2.42	5	2.8	2.42	5
800	2.8	2.42	5	2.8	2.42	5
900	2.9	2.51	4	2.9	2.51	4
1000	3.0	2.60	4	3.0	2.60	4
1200	3.2	2.78	4	3.2	2.78	4

[a] Based on a minimum volume resistivity of 2.0 x 10^{11} Ù.m at 23 °C and the nominal thickness of the dielectric.

Note : For insulated earth conductors exceeding 16 mm² the nominal thickness shall be at least 1.0 mm and the minimum thickness shall be 0.8 mm.

Table 10 – Bedding Thickness and Armour Wire Diameter of Cables Without Lead Sheath

Nominal diameter over core or laid up cores mm		*Thickness of extruded bedding mm*		*Nominal [a] diameter of armour wire*
		Nominal	*Min.*	*mm*
	≤ 10	0.8	0.58	[b]0.9
> 10	≤ 15	0.8	0.58	[b]0.9
> 15	≤ 20	1.2	0.92	[c]1.60
> 20	≤ 25	1.2	0.92	1.60
> 25	≤ 35	1.4	1.09	2.0
> 35	≤ 55	1.6	1.26	2.5
> 45	≤ 60	1.6	1.26	2.5
	> 60	1.6	1.26	3.15

[a] Larger diameter wires may be used if agreed with the purchaser.

[b] Armour wires may be of diameter 0.9 mm or 1.25 mm.

[c] Armour wires may be of diameter 1.25 mm or 1.60 mm.

Table 11 – Bedding Thickness and Armour Wire Diameter of Cables with Lead Sheath

Nominal diameter over core or laid up cores mm		*Thickness of extruded bedding mm*		*Nominal diameter of armour wire[a]*
		Nominal	*Min.*	*mm*
	≤ 20	1.4	1.09	1.6
> 20	≤ 25	1.6	1.26	2.0
> 25	≤ 30	2.0	1.60	2.0
> 30	≤ 40	2.2	1.77	2.0
> 40	≤ 45	2.4	1.94	2.5
> 45	≤ 50	2.4	1.94	2.5
> 50	≤ 60	2.6	2.11	3.15
	> 60	2.6	2.11	3.15

[a] Larger diameter wires may be used if agreed with the purchaser.

PART 4 - XLPE DISTRIBUTION CABLES

ELECTRIC CABLES WITH EXTRUDED SOLID DI-ELECTRIC INSULATION FOR FIXED INSTALLATIONS

(300/500V TO 1900/3 300 V—SPECIFICATION

1 SCOPE

1.1 This Part of the Zambian Standard ZS 688 specifies the requirements for construction, materials, dimensions and electric properties of multicore extruded XLPE insulated cables of rated operating voltages (U_0 / U) 600/1 000 V and 1 900/3 300 V, for use in fixed installations.

1.2 Specific types of cables covered by this Part are multicore XLPE insulated armoured and unarmoured circular cables with protective covering(s).

2. NORMATIVE REFERENCES

In this standard, reference has been made to the following standards:

ZS 756-1, Materials of insulated electric cables and flexible cords – Part 1: Conductors;

ZS 756-2, Materials of insulated electric cables and flexible cords – Part 2: Polyvinyl chloride (PVC);

ZS 756-3, Materials of insulated electric cables and flexible cords – Part 3: Elastomers;

ZS 756-4, Materials of insulated electric cables and flexible cords – Part 4: Cross-linked polyethylene (XLPE);

ZS 756-5, Materials of insulated electric cables and flexible cords – Part 5: Halogen-free, flame-retardant materials;

ZS 756-6, Materials of insulated electric cables and flexible cords – Part 6: Armour; and

ZS 756-7, Materials of insulated electric cables and flexible cords – Part 7: Polyethylene (PE). ZS 771, The preservative treatment of timber.

NOTE:

All standards are subject to revision and, since any reference to a standard is treated as a reference to the latest edition of that standard, parties to agreements based on this part of ZS 688 are encouraged to take steps to ensure the use of the most recent editions of the standards indicated. Information on currently valid national and international standards can be obtained from the Zambia Bureau of Standards.

3 Definitions

For the purposes of this Part of Zambian standard ZS 688 the definitions given in Zambian Standard ZS 688-1 shall apply.

4 REQUIREMENTS

4.1 Cable Operating Voltage

The maximum permissible operating voltage of a cable shall be 600/1 000 V or 1 900/3 300 V.

4.2 *Materials and Construction*

4.2.1 Conductors

Conductors shall be manufactured from annealed copper, or aluminium, as required, and shall comply with the requirements of Zambian standard ZS 756-1.

4.2.2 *Insulation*

4.2.2.1 Material

The insulation shall be of extruded XLPE of the type A or B of ZS 756-4, as required, and shall comply with the requirements of Zambian standard ZS 756-4.

4.2.2.2 Thickness and insulation resistance

4.2.2.2.1 The insulation resistance of the insulating material shall comply with the requirements stated in table 9, as appropriate to the cross-sectional area of the conductor and operating voltage.

4.2.2.2.2 When the thickness of the insulation is determined in accordance with Zambian standard ZS IEC 60811-1-1, the average thickness shall be at least equal to the nominal value stated in table 9, and the minimum thickness at any point may be less than the nominal value provided that the difference does not exceed 0.1 mm + 10 % of the nominal value.

4.2.2.3 Spark testing of insulation

Core insulation shall be continuously spark tested, using the method given in SABS SM 524 at the appropriate spark test voltage stated in table 1, without breakdown of the dielectric.

Table 1 – Spark Test Voltage

Cross-sectional area of the conductor mm²		*Alternating current rms test voltage V[a]*	
Above	*Up to and including*	*600/1 000 V cables*	*1 900/3 300 V cables*
—	—	6 000	12 000
16	16	10 000	12 000
240	240	12 000	12 000
[a]Alternatively, a dc spark test voltage 1.5 times the appropriate ac rms value may be used.			

4.2.3 *Core identification*

4.2.3.1 Identification

Cores shall be identified durably and distinctly by the colouring or numbering of the insulation.

(a) Colour coding: Where colour coding is used, the cores shall be insulated in the colours in table 2.

(b) Numbering: Where numbers are used, the marking shall be in a contrasting colour to that of the insulation, and the interval between any two adjacent numbers or words on the same core shall not exceed 75 mm.

Table 2 – Core Insulation Colour Coding

Number of phase cores	*Colour(s) of phase cores*	*Colour of neutral core*	*Colour of earthing core(if present and not bare)*
1	Red	Black	Green / yellow
2	Red and yellow	Black	Green / yellow
3	Red, yellow and blue	Black	Green / yellow
4 or more	Any base colour except green, with serial numbers (numerals or words)	Numbered as for phase cores	Green / yellow
Note Control cables may have uniquely coloured or numbered cores or both.			

4.2.3.2 Colour application

Colour shall be applied —

(a) throughout the thickness of the insulation; or

(b) in a durable manner on the entire surface of the insulation.

4.2.3.3 Earthing cores

Where an earthing core is not bare, it shall be coloured green and yellow, and the combination of the colours shall be such that one colour shall cover not less than 30 % and not more than 70 % of the surface of the core, and the other cover the remainder of the surface. There shall be no green and yellow coloured core in a two-core cable or in any non-earthing type cable.

NOTE

The combination of green / yellow is reserved exclusively for the identification of the earthing core.

4.2.4 Assembly of cores

4.2.4.1 General

4.2.4.1.1 The cores shall be compactly laid up with an acceptable lay and in the correct sequence of their identification colours or numbers.

4.2.4.1.2 There shall be no turned cores in an assembly of shaped cores.

4.2.4.2 Fillers

Fillers may be applied integrally with the bedding or the sheath, as applicable, and shall be used in the interstices of the cable where necessary to give the completed cable a compact circular cross-section. Filler materials shall be acceptable for the specific type of cable.

4.2.4.3 Binder

A binder may be applied over the laid-up cores, and the material shall be acceptable for the specific type of cable.

4.2.4.4 Concentric conductors

4.2.4.4.1 A concentric conductor shall consist of a single layer of annealed copper wires, which may be tinned, and applied helically around the laid-up cores with an acceptable lay.

4.2.4.4.2 The concentric conductor shall be separated from the laid-up cores by a separator consisting of a covering of an acceptable material. The separator shall be extruded and may include a binder. It shall be possible to strip the separator from the cores without tearing the dielectric.

4.2.4.4.3 There shall be no sunken or protruding wires and the space between adjacent wires shall not exceed 4 mm. An equalising member shall be applied. The equalising member shall consist of one or more annealed copper tapes or wires applied in contact with the concentric conductors and having a suitably short lay. The nominal cross-sectional area of the equalising member shall be at least 5 % of the area of the concentric conductor to which it is applied and shall be regarded as part of the conducting area.

4.2.4.5 *Cross-sectional area of concentric conductors*

4.2.4.5.1 The nominal cross-sectional area of a concentric earth continuity conductor (ECC) shall conform to the appropriate value given in table 3.

4.2.4.5.2 The nominal cross-sectional area of a concentric neutral conductor shall -

(a) in the case of single-core cables, be at least equal to that of the phase conductor; or

(b) in the case of multicore cables, be in accordance with table 3.

Table 3 – Cross-Sectional Area of the Concentric ECCS and Neutral Conductors in Multicore Cables

Cross-sectional area of the phase conductor mm^2	*Areas of ECCs and neutral conductors* mm^2			
	Copper phase conductors		*Aluminium phase conductors*	
	ECC (copper)	Neutral (copper)	ECC (copper)	Neutral (copper)
1.5	1.0	1.5	—	—
2.5	1.5	2.5	—	—
4	2.5	4	—	—
6	4	6	—	—
10	6	10	—	—
16	10	16	6	10
25	16	16	6	10
35	16	16	6	10
50	25	25	16	16
70	35	35	25	25
95	50	50	35	35
120	70	70	35	35
150	70	70	50	50
185	95	95	70	70
240	120	120	70	70
300	150	150	95	95
400	185	185	120	120

4.2.5 *Protective coverings*

4.2.5.1 General

Non-metallic coverings shall consist of a continuous extrudate that closely fits but does not adhere to the underlying core or laid-up cores or armour. The surface of the extrudate shall have a smooth finish and its profile shall be uniform and appropriate to the type of cable.

4.2.5.2 *Lead or lead alloy sheath*

4.2.5.2.1 Material

Where a metallic sheath is required it shall be of lead or of lead alloy of type E (see annex B of EN 12548:1999), as required, and when it is tested in accordance with SABS SM 1281-2, the composition shall be as given in the appropriate columns of table 4. Its malleability shall be such that, when the sheath is tested in accordance with SABS SM 1281-2, the sheath does not split or crack when the internal diameter of the expanded section reaches 150 % of the original internal diameter.

4.2.5.2.2 Construction:

(a) a heat barrier shall be applied over the core assembly before the metallic sheath is applied, and shall consist of one of the following:

(i) a layer of tape (cotton, proofed cloth, crêpe paper or compatible synthetic material) applied helically and of total thickness of at least 0.3 mm; or

(ii) a bedding in accordance with 4.2.5.3, except that the nominal thickness shall be 1.0 mm.

(b) the metallic sheath shall be in the form of a continuous tube that is impervious to moisture, reasonably close fitting and free from defects.

Table 4 – Composition of Metallic Sheath

Element	*Content* %			
	Type of material			
	Lead alloy E[a]		*Lead*	
	Min.	*Max.*	*Min.*	*Max.*
Antimony	0.15	0.25	—	0.20
Tin	0.35	0.45	—	0.10
Copper	—	0.06	—	0.06
Bismuth	—	0.05	—	0.05
Tellurium	—	0.005	—	0.010
Silver	—	0.005	—	0.010
Zinc	—	0.002	—	0.002
Total other elements[b]	—	0.01	—	0.01
Lead	Remainder	Remainder	99.7	—

[a] Lead alloy E is recommended for installations subject to vibration.

[b] All elements other than those specified in the table.

4.2.5.2.2 Thickness

When the thickness of the sheath is determined in accordance with Zambian Standard ZS IEC 60811-1-1, it shall be at least equal to the value obtained from the following formula:

$$t = 0.033\ D + 0.7 \text{ mm (minimum 1.2 mm)}$$

where—

t is the thickness of sheath, in millimeters; and

D is the calculated diameter over the core or over the laid-up and filled cores, in millimeters

Note: Round off the calculated values of the thickness to the nearest 0.1 mm.

4.2.5.3 Bedding of armoured cable

4.2.5.3.1 Material

Bedding shall consist of a smooth surfaced, circular layer of PVC type B1 of Zambian Standard ZS 756-2. A full cover separating tape shall be applied over the cores under the bedding. The bedding shall not adhere to the underlying cores or binder.

4.2.5.3.2 Thickness

(a) Unless otherwise stated, the nominal and minimum thickness of the bedding shall be as given in columns 2 and 3 of table 10 or 11, as appropriate.

(b) When the average thickness of the bedding is determined in accordance with ZS IEC 60811-1-1, it shall be at least equal to the nominal value, and the minimum thickness at any point may be less than the nominal value provided that the difference does not exceed 0.1 mm + 15 % of the nominal value.

4.2.5.4 Armour

When so required, the cable shall be armoured, and the armouring shall comply with the following:

(a) material: Armour shall consist of round wire of galvanized steel, which shall comply with Zambian Standard ZS 756-6;

(b) armouring: the nominal diameter of armour wire shall be as given in column 4 of table 10 or 11, as relevant. Armour wire shall be applied with an acceptable lay, without any appreciable space between adjacent wires, and there shall be no crossed, riding or protruding wire. Joints in the wire shall be made in an acceptable workmanlike manner without sharp edges or protruding points, and multiple joints shall be acceptably staggered.

(c) earth continuity conductor: When an improved conductivity in the earth continuity circuit of steel wire armoured multicore cables is required, an appropriate number of steel wires may be replaced by tinned hard-drawn copper wires of the same nominal diameter. The copper wires shall comply with the relevant requirements of Zambian Standard ZS 756-1.

The following requirements shall apply:

(i) the copper wires shall be of diameter equal to that of the armour, and of number as given in table 5, appropriate to the cross-sectional area of the conductor; and

(ii) the copper wires shall be grouped together and shall not be distributed amongst the armour wires. Where eight or more armour wires are replaced by copper wires, the copper wires shall be arranged in two diametrically opposed groups to allow for a more even distribution of the clamping forces when a mechanical gland is used to terminate the cable.

Table 5 – EARTH CONTINUITY CONDUCTOR IN WIRE ARMOUR

Nominal diameter of armour wire mm	*Cross-sectional area of the earth conductor mm²*														
	1.0	1.5	2.5	4	6	10	16	25	35	50	70	95	120	150	185
	Number of earth continuity conductor wires														
0.9	2	3	4	7	10	17	26	41	57	—	—	—	—	—	—
1.25	2	2	3	4	5	9	14	21	30	40	57	—	—	—	—
1.6	2	2	2	2	3	6	9	13	18	25	35	49	61	76	95
2.0	—	—	—	—	—	—	—	9	12	16	23	31	39	49	61
2.5	—	—	—	—	—	—	—	—	8	10	15	20	25	31	39
3.15	—	—	—	—	—	—	—	—	—	—	9	13	16	20	25
Material	*Cross-sectional area of the Phase conductor mm²*														
Copper	1.5	2.5	4	6	10	16	25 35	50	70	95	120 150	185	240	300	400
Aluminium	—	—	—	—	16 25 35	—	50	70	95 120	150	185 240	300	400	—	—

4.2.5.5 *Outer Sheath*

4.2.5.5.1 Material:

The sheath shall consist of either PVC type S2 of Zambian Standard ZS 756-2 or polyethylene type PS1 or PS2 of ZS 756-7.

4.2.5.5.2 Thickness:

(a) the nominal thickness of the sheath shall be as given in table 6; and

(b) when the average thickness of the sheath is determined in accordance with Zambian Standard ZS IEC 60811—1, it shall be at least equal to the nominal value, and the minimum thickness at any point may be less than the nominal value provided that the difference does not exceed:

(i) 0.1 mm + 15 % of the nominal value in the case of an unarmoured cable; or

(ii) 0.2 mm + 20 % of the nominal value in the case of an armoured cable

Table 6 – Thickness of Outer Sheath

Nominal diameter under sheat mm		*Thickness of sheath mm*					
		Unarmoured cable		*Armoured cable*			
				Without lead sheath		*With lead sheath*	
		Nominal	*Min.*	*Nominal*	*Min.*	*Nominal*	*Min.*
	≤ 10	1.6	1.26	1.4	0.92	1.6	1.08
> 10	≤ 15	1.8	1.43	1.5	1.00	1.6	1.08
> 15	≤ 20	1.8	1.43	1.6	1.08	1.6	1.08
> 20	≤ 25	2.0	1.60	1.7	1.16	1.8	1.24
> 25	≤ 30	2.0	1.60	1.8	1.24	2.0	1.40
> 30	≤ 35	2.2	1.77	2.0	1.40	2.2	1.56
> 35	≤ 40	2.2	1.77	2.2	1.56	2.4	1.72
> 40	≤ 45	2.4	1.94	2.4	1.72	2.6	1.88
> 45	≤ 50	2.6	2.11	2.4	1.72	2.8	2.04
> 50	≤ 55	2.8	2.28	2.6	1.88	3.0	2.20
> 55	≤ 60	3.0	2.45	2.8	2.04	3.0	2.20
	> 60	3.4	2.79	3.0	2.20	3.0	2.20

4.3 *Electrical Requirements for Finished Cables*

4.3.1 Conductor resistance

The dc resistance of each conductor shall not exceed the appropriate maximum value given in Zambian standard ZS 756-1.

4.3.2 Voltage withstand

When a cable is factory tested in accordance with Zambian standard ZS 769, each core of the cable shall withstand, for 10 min without breakdown of the dielectric, a test voltage of the appropriate value given in column 3 or 4 of table 7. Alternatively, the test may be conducted for 5 min at a test voltage of the appropriate value given in column 5 or 6 of the table.

Table 7 – Test Voltages

Cables		*Alternating current rms test voltage V*			
Rated voltage V	*Type or cross-sectional area*	*10 minute test*		*5 minute test*	
		Between conductors	*Between any conductor and earth*	*Between conductors*	*Between any conductor and earth*
600 / 1 000	Cables of cross sectional areanot exceeding 16 mm^2	2 000	2 000	3 000	3 000
600 / 1 000	Cables of cross sectional area 25 mm^2 and above	3 000	3 000	4 500	4 500
1 900 / 3 300	Cables of all sizes	6 700	3 900	10 000	5 800

4.3.3 Di-electric resistance

When a cable is tested in accordance with Zambian Standard ZS 765, the insulation resistance of the cable shall be at least 100 MÙ km at 23 ºC.

4.4 *Additional Requirements for Fire Retardant Cables*

4.4.1 Reduced flame propagation

When a cable that is required to have reduced flame propagation properties is tested in accordance with Zambian Standard ZS 768, the height of the charred or affected portion above the bottom edge of the burner shall not exceed 2.5 m. (See also B.3 of ZS 688-1).

4.4.2 Reduced smoke emission

When a cable that is required to have reduced smoke emission properties is tested in accordance with Zambian standard ZS 767, the light transmittance shall exceed the following values throughout the test:

Number of specimens of cable tested	*Light Transmittance*
4	50 %
3	60 %
2	60 %
1	70 %

4.4.3 Reduced halogen emission

When a cable that is required to have reduced halogen emission properties is tested in accordance with Zambian standard ZS 767, the evolution of halogen gas from the bedding and sheathing obtained from the finished cable shall not exceed 150 mg/g (15 % (m/m)).

4.5 *Compatibility of Compounds*

Cable materials that are intended to be in contact with one another shall be compatible. Where the cable construction is such that PVC and other compounds are used in the same cable, the compounds shall be separated by a compatible barrier tape, or the PVC compound shall be so modified as to prevent any plasticizer migration. Plasticizer migration can lead to reduction or loss of desired properties of the other components.

5. SPECIFIC REQUIREMENTS FOR TYPES OF CABLE IN COMMON USE

5.1 *Aluminium Laminate Sheathed Cables (1 900/3 300 V)*

5.1.1 Cables shall have 2 or 3 cores, coloured as stated in table 2, with a bare earth continuity conductor. The earth continuity conductor shall be tinned annealed copper and shall comply with the requirements given in table 3.

5.1.2 Aluminium laminate shall consist of longitudinally applied aluminium tape of minimum thickness 0.1 mm, covered by the outer sheath (see (c)). The aluminium tape shall be laminated with a material suitable for bonding with the outer sheath, and shall be in close contact with the bare earth.

5.1.3 The sheath shall consist of UV stabilized polyethylene type PS1 or PS2 of Zambian standard ZS 756-7, and shall be bonded to the aluminium laminate.

6 INSPECTION AND METHODS OF TEST

6.1 General

For convenience, the properties to be tested, the test category, the test methods and the sub-clause giving the requirements are listed in table 8:

Table 8 – List of Tests to be Conducted

Component(s)	*Test property*	*Test category*	*Test method given in*	*Requirement subclause*
Conductor	Construction	S	ZS 756-1	4.2.1
Insulation	Physical properties	S	ZS 756-2	4.2.2.1
	Thickness	S	ZS IEC 60811-1-1	4.2.2.2
	Spark test	R	ZS 764	4.2.2.3
	Core identification	R,S	Visual examination	4.2.3
	Assembly of cores	R	Visual examination	4.2.4
Bedding	Physical properties	S	ZS 756-2	4.2.5.3
	Thickness	S	ZS IEC 60811-1-1	4.2.5.3
	Halogen	T	ZS 767	4.4.3
Lead sheath	Construction	S	ZS 769-2	4.2.5.2
	Belling	S	ZS 769-2	4.2.5.2
	Thickness	S	ZS IEC 60811-1-1	4.2.5.2 (c)
Armour	Amour Wire diameter	S	ZS 756-6	4.2.5.4
	Mass of Zinc coating	S	ZS 756-6	
	Adhesion of Zinc coating	S	ZS 756-6	
	Tensile strength	S	ZS 756-6	
	Elongation at break	S	ZS 756-6	
Sheath	Physical properties	S	ZS 756-2	4.2.5.5
	Thickness	S	ZS IEC 60811-1-1	4.2.5.5
	Halogen gas	T	ZS 767	4.4.3

Finished cable	Marking	R	Visual examination	SABS1507-1 4.2.1
	Conductor resistance	R	ZS 756-1	4.3.1
	Voltage withstand	R	ZS 769-3	4.3.2
	Dielectric resistance	S	ZS 765	4.3.3
	Fire propagation	T	ZS 768	4.4.1
	Smoke emission	T	ZS 767	4.4.2

NOTE 1: In column 3 of this table, a code letter is given that identifies the tests as suitable for use as routine tests (R), sample tests (S) or type tests (T), but compliance with the requirements of the specification may only be fully determined from the results of tests carried out on samples of completed cable(s), using all the test methods given and a sampling procedure agreed upon. During production control, a manufacturer may use any tests considered necessary to ensure compliance with the specification but, in the case of a dispute, only the appropriate standard test methods may be used.

NOTE 2: In the administration of the standardization mark scheme, the frequency of testing required and the tests to be used are the subject of a separate agreement between the Authority administering this standard and the permit holder.

6.2 *Conditions of Test*

6.2.1 All tests are to be carried out at ambient temperature and pressure, unless otherwise stated in the test method.

6.2.2 Unless otherwise required in the test method, the frequency of the alternating test voltage used shall be approximately 50 Hz, and the waveform shall be substantially sinusoidal.

Table 9 – THICKNESS OF XLPE INSULATION

Cross-sectional area of the conductor mm²	*Voltage rating*			
	600/1 000 V		*1 900/3 300 V*	
	Thickness of insulation mm		*Thickness of insulation mm*	
	Nominal	*Min.*	*Nominal*	*Min.*
1.0	0.7	0.53	—	—
1.5	0.7	0.53	—	—
2.5	0.7	0.53	—	—
4	0.7	0.53	—	—
6	0.7	0.53	—	—
10	0.7	0.53	2.0	1.70
16	0.7	0.53	2.0	1.70
25	0.9	0.71	2.0	1.70
35	0.9	0.71	2.0	1.70
50	1.0	0.80	2.0	1.70
70	1.1	0.89	2.0	1.70

95	1.1	0.89	2.0	1.70
120	1.2	0.98	2.0	1.70
150	1.4	1.16	2.0	1.70
185	1.6	1.34	2.0	1.70
240	1.7	1.43	2.0	1.70
280	1.8	1.52	2.0	1.70
300	1.8	1.52	2.0	1.70
380	2.0	1.70	2.0	1.70
400	2.0	1.70	2.0	1.70
480	2.2	1.88	2.2	1.88
500	2.2	1.88	2.2	1.88
600	2.4	2.06	2.4	2.06
630	2.4	2.06	2.4	2.06
740	2.5	2.15	2.5	2.15
800	2.6	2.24	2.6	2.24
960	2.7	2.33	2.7	2.33
1000	2.8	2.42	2.9	2.42
1200	2.9	2.51	2.9	2.51

Table 10 – Bedding Thickness and Armour Wire Diameter of Cables without Lead Sheath

Nominal diameter over core or laid up cores mm		*Thickness of extruded bedding mm*		*Nominal [a] diameter of armour wire mm*
		Nominal	*Min.*	
	≤ 10	0.8	0.58	[b]0.9
> 10	≤ 15	0.8	0.58	[b]0.9
> 15	≤ 20	1.2	0.92	[c]1.60
> 20	≤ 25	1.2	0.92	1.60
> 25	≤ 35	1.4	1.09	2.0
> 35	≤ 55	1.6	1.26	2.5
> 45	≤ 60	1.6	1.26	2.5
	> 60	1.6	1.26	3.15

[a] Larger diameter wires may be used if agreed with the purchaser.

[b] Armour wires may be of diameter 0.9 mm or 1.25 mm.

[c] Armour wires may be of diameter 1.25 mm or 1.60 mm.

Table 11 —Bedding Thickness and Armour Wire Diameter of Cables with Lead Sheath

Nominal diameter over core or laid up cores mm		*Thickness of extruded bedding* mm		*Nominal diameter of armour wire*[a] mm
		Nominal	*Min.*	
	≤ 20	1.4	1.09	1.6
> 20	≤ 25	1.6	1.26	2.0
> 25	≤ 30	2.0	1.60	2.0
> 30	≤ 40	2.2	1.77	2.0
> 40	≤ 45	2.4	1.94	2.5
> 45	≤ 50	2.4	1.94	2.5
> 50	≤ 60	2.6	2.11	3.15
	> 60	2.6	2.11	3.15

[a] Larger diameter wires may be used if agreed with the purchaser.

PART 5 —Halogen-free distribution cables Specification

Electric Cables with Extruded Solid Di-Electric Insulation for Fixed Installations

(300/500 V to 1 900/3 300 V)

1 SCOPE

1.1 This Part of Zambian Standard ZS 688 covers the requirements for construction, materials, dimensions and electric properties of single-core and multicore halogen-free cables of rated operating voltages (U_0/U) 600/1 000 V to 1 900/3 300 V, for use in fixed installations.

1.2 Specific types of cables covered by this Part of Zambian standard ZS 688 are single and multicore insulated armoured and unarmoured circular cables with protective covering(s). The cables are also flame retardant, and emit no halogen gases and little smoke under exposure to fire.

2 NORMATIVE REFERENCES

In this standard, reference has been made to the following standards:

ZS EN 12548 Lead and lead alloys – Lead alloy ingots for electric cable sheathing and for sleeves;

ZS 756-1 Materials of insulated electric cables and flexible cords – Part 1: Conductors;

ZS 756-4 Materials of insulated electric cables and flexible cords – Part 4: Cross-linked polyethylene (XLPE);

ZS 756-5 Materials of insulated electric cables and flexible cords – Part 5: Halogen-free flame retardant materials;

ZS 756-6 Materials of insulated electric cables and flexible cords - Part 6: Armour;

ZS 688-1 Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) – Part 1: General;

ZS IEC 60811-1-1 Common test methods for insulating and sheathing materials of electric and optical cables – Part 1-1: Methods for general application – Measurement of thickness and overall dimensions – Tests for determining the mechanical properties;

ZS IEC 61034-2 Measurement of smoke density of cables burning under fire conditions – Part 2: Test procedure and requirements;

ZS 764 Alternating current spark test on electric cables and cords;

ZS 765 Dielectric resistance of electric cables;

ZS 767 Acid gas evolved during combustion of cable materials;

ZS 768 Resistance of cables and cords to flame propagation – Bunched cables and cords;

ZS 769-2 test methods for impregnated paper-insulated electric cables – Part 2: Tests on metallic sheaths; and

ZS 769-3 test methods for cross-linked polyethylene (XLPE) insulated electric cables – Part 3: Tests on finished cable.

NOTE

All standards are subject to revision and, since any reference to a standard is treated as a reference to the latest edition of that standard, parties to agreements based on this Part of Zambian standard ZS 688 are encouraged to take steps to ensure the use of the most recent editions of the standards indicated. Information on currently valid national and international standards can be obtained from the Zambia Bureau of Standards.

3 DEFINITIONS

For the purposes of this Part of Zambian standard ZS 688 the definitions given in Zambian standard ZS 688-1 shall apply.

4 REQUIREMENTS

4.1 *Cable Operating Voltage*

The maximum permissible operating voltage of a cable shall be 600/1 000 V or 1 900/3 300 V.

4.2 *Materials and Construction*

4.2.1 Conductors

Conductors shall be of plain annealed copper, or aluminium, as required, and they shall comply with the requirements of Zambian standard ZS 756-1.

4.2.2 *Insulation*

4.2.2.1 Material

The insulation shall be of extruded material (XLPE, HFDI or HFD2) complying with the requirements of Zambian standard ZS 756-4 or ZS 756-5 (see table 12).

4.2.2.2 *Thickness and insulation resistance*

4.2.2.2.1 The insulation resistance of the insulating material shall comply with the requirements stated in table 9, as appropriate to the type of material, cross-sectional area of the conductor and operating voltage.

4.2.2.2.2 When the thickness of the insulation is determined in accordance with Zambian Standard ZS IEC 60811-1-1, the average thickness shall be at least equal to the nominal value stated in table 9, and the minimum thickness at any point may be less than the nominal value provided that the difference does not exceed 0.1 mm + 10 % of the nominal value.

4.2.2.2 Spark testing of insulation

Core insulation shall have been continuously spark tested, using the method stated in Zambian Standard ZS 764 at the appropriate spark test voltage stated in table 1, without breakdown of the dielectric.

Table 1 – Spark Test Voltage

Cross-sectional area of the conductor mm²		*Alternating current rms test voltage* V[a]	
Above	*Up to and including*	*600/1 000V cables*	*1 900/3 300 V cables*
—	16	6 000	12 000
16	240	10 000	12 000
240	—	12 000	12 000
Alternatively, a dc spark test voltage 1.5 times the appropriate ac rms value may be used.			

4.2.3 *Core Identification*

4.2.3.1 Identification

Cores shall be identified durably and distinctly by the colouring or numbering of the insulation as follows:

(a) colour coding: where colour coding is used, the cores shall be insulated in the colours stated in table 2; and

(b) Numbering: where numbers are used, the marking shall be in a contrasting colour to that of the insulation, and the interval between any two adjacent numbers or words on the same core shall not exceed 75 mm.

Table 2 – Core Insulation Colour Coding

Number of phase cores	*Colour(s) of phase cores*	*Colour of neutral core core*	*Colour of earthing (if present)*
1	Red	Black	Green / yellow
2	Red and yellow	Black	Green / yellow
3	Red, yellow and blue	Black	Green / yellow
4 or more	Any base colour except green, with serial numbers (numerals orwords)	Numbered as for phase cores	Green / yellow
Note: Control cables may have uniquely coloured or numbered cores or both.			

4.2.3.2 Colour application

Colour shall be applied —

(a) throughout the thickness of the insulation; or

(b) in a durable manner on the entire surface of the insulation.

4.2.3.3 Earthing cores

An earthing core shall be coloured green and yellow, and the combination of the colours shall be such that one colour covers not less than 30 % and not more than 70 % of the surface of the core, and the other covers the remainder of the surface. There shall be no green and yellow coloured core in a two-core cable or in any non-earthing type cable.

NOTE:

The combination of green/yellow is reserved exclusively for the identification of the earthing core.

4.2.4 *Assembly of Cores*

4.2.4.1 General

4.2.4.1.1 The cores of a multicore cable shall be compactly laid up with an acceptable lay and in the correct sequence of their identification colours or numbers.

4.2.4.1.2 There shall be no turned cores in an assembly of shaped cores.

4.2.4.2 Fillers

Fillers may be applied integrally with the bedding or the sheath, as applicable, and shall be used in the interstices of the cable where necessary to give the completed cable a compact circular cross-section. Filler materials shall be acceptable for the specific type of cable.

4.2.4.3 Binder

A binder may be applied over the laid-up cores, and the material shall be acceptable for the specific type of cable.

4.2.4.4 Concentric conductors

4.2.4.4.1 A concentric conductor shall consist of a single layer of annealed copper wires, which may be tinned, and applied helically around the laid-up cores with an acceptable lay.

4.2.4.4.2 The concentric conductor shall be separated from the laid-up cores by a separator consisting of a covering of material acceptable for the specific type of cable. The separator shall be extruded and may include a binder. It shall be possible to strip the separator from the cores without tearing the dielectric.

4.2.4.4.3 There shall be no sunken or protruding wires and the space between adjacent wires shall not exceed 4 mm. An equalising member shall be applied. The equalising member shall consist of one or more annealed copper tapes or wires applied in contact with the concentric conductors and having a suitable short lay. The nominal cross-sectional area of the equalising member shall be at least 5 % of the area of the concentric conductor to which it is applied and shall be regarded as part of the conducting area.

4.2.4.5 *Cross-sectional area of concentric conductors*

4.2.4.5.1 The nominal cross-sectional area of a concentric earth continuity conductor (ECC) shall conform to the appropriate value given in table 3.

4.2.4.5.2 The nominal cross-sectional area of a concentric neutral conductor shall,

(a) in the case of single-core cables, be at least equal to that of the phase conductor, or

(b) in the case of multicore cables, be in accordance with table 3.

Table 3 – Sizes of Concentric ECCS and Neutral Conductors in Multicore Cables

Cross-sectional area of the Phase conductor mm²	*Areas of ECCs and neutral conductors mm²*			
	Copper phase conductors		*Aluminium phase conductors*	
	ECC Copper	*Neutral Copper*	*ECC Copper*	*Neutral Copper*
1.5	1.0	1.5	—	—
2.5	1.5	2.5	—	—
4	2.5	4	—	—
6	4	6	—	—
10	6	10	—	—
16	10	16	6	10
25	16	16	6	10
35	16	16	6	10
50	25	25	16	16
70	35	35	25	25
95	50	50	35	35
120	70	70	35	35
150	70	70	50	50
185	95	95	70	70
240	120	120	70	70
300	150	150	95	95
400	185	185	120	120

4.2.5 *Protective Coverings*

4.2.5.1 General

Non-metallic coverings shall consist of a continuous extrudate that closely fits but does not adhere to the underlying core or laid-up cores or armour. The surface of the extrudate shall have a smooth finish and its profile shall be uniform and appropriate to the type of cable.

4.2.5.2 Lead or lead alloy sheath

4.2.5.2.1 Material: Where a metallic sheath is required it shall be of lead or of lead alloy of type E (see annex B of ZS EN 12548:1999), as required, and when it is tested in accordance with ZS 769-2 the composition shall be as given in the appropriate columns of table 4. Its malleability shall be such that, when the sheath is tested in accordance with Zambian Standard ZS 769-2 the sheath does not split or crack when the internal diameter of the expanded clause reaches 150 % of the original internal diameter.

4.2.5.2.2 Construction:

(a) A heat barrier shall be applied over the core assembly before the metallic sheath is applied, and shall consist of one of the following:

(1) a layer of tape (cotton, proofed cloth, crêpe paper or compatible synthetic material) applied helically and of total thickness at least 0.3 mm; or

(2) a bedding of extruded halogen free material of nominal thickness at least 1.0 mm.

(b) The metallic sheath shall be in the form of a continuous tube that is impervious to moisture, reasonably close fitting and free from defects.

Table 4 – Composition of Metallic Sheath

Element	*Content%*			
	Type of material			
	*Lead alloy E**		*Lead*	
	Min.	*Max.*	*Min.*	*Max.*
Antimony	0.15	0.25	—	0.20
Tin	0.35	0.45	—	0.10
Copper	—	0.06	—	0.06
Bismuth	—	0.05	—	0.05
Tellurium	—	0.005	—	0.010
Silver	—	0.005	—	0.010
Zinc	—	0.002	—	0.002
Total other elements[b]	—	0.01	—	0.01
Lead	Remainder	Remainder	99.7	—

* Lead alloy E is recommended for installations subject to vibration.

[b] All elements other than those specified in the table.

4.2.5.2.3 Thickness:

When the thickness of the sheath is determined in accordance with Zambian Standard ZS IEC 60811-1-1, it shall be at least equal to the value obtained from the following formula:

$t = 0.033 D + 0.7$ mm (minimum 1.2 mm)

where —

t is the thickness of sheath, in millimeters; and

D is the calculated diameter over the core or over the laid-up and filled cores, in millimeters.

Note Round off the calculated values of the thickness t to the nearest 0.1 mm

4.2.5.3 Bedding of armoured cable

4.2.5.3.1 Material: Bedding shall consist of a smooth surfaced circular layer of material that complies with the requirements of ZS 756-5 (see table 12). The bedding shall not adhere to the underlying cores or binder.

4.2.5.3.2 Thickness:

(a) the nominal and minimum thickness of the bedding shall be as given in table 10 or 11, as relevant; and

(b) when the average thickness of the bedding is determined in accordance with ZS IEC 60811-1-1, it shall be at least equal to the nominal value, and the minimum thickness at any point may be less than the nominal value, except provided that the difference shall not exceed 0.1 mm + 15 % of the nominal value.

4.2.5.4 Armour

When so required, the cable shall be armoured, and the armouring shall comply with the following:

(a) Material: Armour shall consist of round wire of galvanized steel or aluminium, as required, and shall comply with ZS 756-6.

(b) Armouring: The nominal diameter of armour wire shall be as given in table 10 or 11, as relevant. Armour wire shall be applied with an acceptable lay, without any appreciable space between adjacent wires, and there shall be no crossed, riding or protruding wire. Joints in the wire shall be made to an acceptable standard of workmanship without sharp edges or protruding points, and multiple joints shall be acceptably staggered.

(c) Type of armour wire:

(i) For single-core cables, the armour shall be of non-magnetic wire.

(ii) For multicore cables the armour shall be of galvanized steel wire, except as allowed for in paragraph*(d)*.

(d) Earth continuity conductor: When an improved conductivity in the earth continuity circuit of steel wire armoured multicore cables is required, an appropriate number of steel wires may be replaced by tinned hard-drawn copper wires of the same nominal diameter. The copper wires shall comply with the relevant requirements of ZS 756-1.

The following requirements shall apply:

(i) The copper wires shall be of diameter equal to that of the armour, and of number as given in table 5, appropriate to the cross-sectional area of the conductor.

(ii) The copper wires shall be grouped together and shall not be distributed amongst the armour wires. Where eight or more armour wires are replaced by copper wires, the copper wires shall be arranged in two diametrically opposed groups to allow for a more even distribution of the clamping forces when a mechanical gland is used to terminate the cable.

Table 5 – Earth Continuity Conductor in Wire Armour

Nominal diameter of armour wire mm	*Cross-sectional area of the earth conductor* mm^2														
	1.0	1.5	2.5	4	6	10	16	25	35	50	70	95	120	150	185
	Number of earth continuity conductor wires														
0.9	2	3	4	7	10	17	26	41	57	—	—	—	—	—	—
1.25	2	2	3	4	5	9	14	21	30	40	57	—	—	—	—
1.6	2	2	2	2	3	6	9	13	18	25	35	49	61	76	95
2.0	—	—	—	—	—	—	—	9	12	16	23	31	39	49	61
2.5	—	—	—	—	—	—	—	—	8	10	15	20	25	31	39
3.15	—	—	—	—	—	—	—	—	—	—	9	13	16	20	25
Material	*Cross-sectional area of the Phase conductor* mm^2														
Copper	1.5	2.5	4	6	10	16	25 35	50	70	95	120 150	185	240	300	400
Aluminium	—	—	—	—	16 25 35	—	50	70	95 120	150	185 240	300	400	—	—

4.2.5.5 Outer sheath

4.2.5.5.1 Material: The sheath shall consist of an extruded layer of material that complies with the requirements of Zambian Standard ZS 756-5 (see table 12).

4.2.5.5.2 Thickness:

(a) the nominal and minimum thickness of the sheath shall be as given in table 6; and

(b) when the average thickness of the sheath is determined in accordance with ZS IEC 60811-1-1, it shall be at least equal to the nominal value, and the minimum thickness at any point may be less than the nominal value except that the difference shall not exceed either of the following:

(i) 0.1 mm + 15 % of the nominal value in the case of an unarmoured cable; or

(ii) 0.2 mm + 20 % of the nominal value in the case of an armoured cable.

Table 6 – Thickness of Outer Sheath

Nominal diameter under sheat mm	*Thickness of sheath mm*					
	Unarmoured cable		*Armoured cable*			
			Without lead sheath		*With lead sheath*	
	Nominal	*Min.*	*Nominal*	*Min.*	*Nominal*	*Min.*
≤ 10	1.6	1.26	1.4	0.92	1.6	1.08
> 10 ≤ 15	1.8	1.43	1.5	1.00	1.6	1.08
> 15 ≤ 20	1.8	1.43	1.6	1.08	1.6	1.08
> 20 ≤ 25	2.0	1.60	1.7	1.16	1.8	1.24
> 25 ≤ 30	2.0	1.60	1.8	1.24	2.0	1.40
> 30 ≤ 35	2.2	1.77	2.0	1.40	2.2	1.56
> 35 ≤ 40	2.2	1.77	2.2	1.56	2.4	1.72
> 40 ≤ 45	2.4	1.94	2.4	1.72	2.6	1.88
> 45 ≤ 50	2.6	2.11	2.4	1.72	2.8	2.04
> 50 ≤ 55	2.8	2.28	2.6	1.88	3.0	2.20
> 55 ≤ 60	3.0	2.45	2.8	2.04	3.0	2.20
> 60	3.4	2.79	3.0	2.20	3.0	2.20

4.3 *Electrical Requirements for Finished Cables*

4.3.1 Conductor Resistance

The d.c. resistance of each conductor shall not exceed the appropriate maximum value given in ZS 756-1.

4.3.2 Voltage Withstand

When a cable is factory tested in accordance with ZS 769-3 each core of the cable shall withstand, for 10 min without breakdown of the dielectric, a test voltage of the appropriate value given in column 3 or 4 of table 7. Alternatively, the test may be conducted for 5 min at a test voltage of the appropriate value given in column 5 or 6 of the table.

Table 7 – Test Voltages

Cables		*Alternating current rms test voltage V*			
Rated voltage V	*Type or cross-sectional area*	*10 minute test*		*5 minute test*	
		Between conductors	*Between any conductor and earth*	*Between conductors*	*Between any conductor and earth*
600 / 1 000	Cables of cross sectional areanot exceeding 16 mm^2	2 000	2 000	3 000	3 000
600 / 1 000	Cables of cross sectional area 25 mm^2 and above	3 000	3 000	4 500	4 500
1 900 / 3 300	Cables of all sizes	6 700	3 900	10 000	5 800

4.3.3 *Di-Electric Resistance*

When a cable is tested in accordance with Zambian Standard ZS 765, the insulation resistance of the cable shall be at least equal to the value given in the appropriate columns of table 9.

4.4 *Other Requirements for Finished Cables*

4.4.1 Reduced Flame Propagation

When a cable that is required to have reduced flame propagation properties is tested in accordance with Zambian Standard ZS 768, the height of the charred or affected portion above the bottom edge of the burner shall not exceed 2.5 m. (See also B.3 of ZS 688-1).

4.4.2 Reduced Smoke Emission

When a cable that is required to have reduced smoke emission properties is tested in accordance with ZS IEC 61034-2, the light transmittance shall exceed the following values throughout the test:

Number of specimens of cable tested	*Light transmittance*
4	50 %
3	60 %
2	60 %
1	70 %

4.4.3 Halogen Emission

When the cable that is tested in accordance with ZS 767, the evolution of halogen gas from the insulation, filling, bedding and sheathing obtained from the finished cable shall not lead to a pH value lower than 3.5 and conductivity higher than 100 ìs/cm

.5. INSPECTION AND METHODS OF TEST

5.1 General

For convenience, the properties to be tested, the test category, the test methods and the sub-clause giving the requirements are listed in table 8:

Table 8 ¯List of Tests to be Conducted

Component(s)	*Test property*	*Test category*	*Test method given in*	*Requirement subclause*
Conductor	Construction	S	ZS 756-1	4.2.1
	Physical properties	S	ZS 756-4 and ZS 756-5	4.2.2.1
	Thickness	S	ZS IEC 60811-1-1	4.2.2.2
	Spark test	R	ZS 764	4.2.2.3
	Core identification	R,S	Visual examination	4.2.3
Insulation	Assembly of cores	R	Visual examination	4.2.4
Bedding	Physical properties	S	ZS 756-5	4.2.5.3
	Thickness	S	ZS IEC 60811-1-1	4.2.5.3
	Halogen gas	T	ZS 767	4.4.3
Filler and binder	Halogen gas	T	ZS 767	4.4.3
	Composition	S	ZS 769-2	4.2.5.2
	Belling	S	ZS 769-2	4.2.5.2
Lead sheath	Thickness	S	ZS IEC 60811-1-1	4.2.5.2 (c)
Armour	Amour			
	Wire diameter	S	ZS 756-6	4.2.5.4
	Mass of Zinc coating	S	ZS 756-6	
	Adhesion of Zinc coating	S	ZS 756-6	
	Tensile strength	S	ZS 756-6	
	Elongation at break	S	ZS 756-6	
Outer Sheath	Physical properties	S	ZS 756-2	4.2.5.5
	Thickness	S	ZS IEC 60811-1-1	4.2.5.5
	Halogen	T	ZS 767	4.4.3
Finished cable	Marking	R	Visual examination	ZS 688-1: 4.2.1
	Conductor resistance	R	ZS 756-1	4.3.1
	Voltage withstand	R	ZS 769-3	4.3.2
	Dielectric resistance	S	ZS 765	4.3.3
	Fire propagation	T	ZS 768	4.4.1
	Smoke emission	T	ZS IEC 61034-2	4.4.2

Note 1 In column 3 of this table, a code letter is given that identifies the tests as suitable for use as routine tests (R), sample tests (S) or type tests (T), but compliance with the requirements of the specification may only be fully determined from the results of tests carried out on samples of completed cable(s), using all the test methods given and a sampling procedure agreed upon. During production control, a manufacturer may use any tests considered necessary to ensure compliance with the specification but, in the case of a dispute, only the appropriate standard test methods may be used.

Note 2 In the administration of the standardisation mark scheme, the frequency of testing required and the tests to be used are the subject of a separate agreement between the Authority administering this standard and the permit holder.

5.2 *Conditions of Test*

5.2.1 All tests are to be carried out at ambient temperature and pressure, unless otherwise stated in the test method.

5.2.2 Unless otherwise required in the test method, the frequency of the alternating test voltage used shall be approximately 50 Hz, and the waveform shall be substantially sinusoidal.

Table 9 – Thickness and Insulation Resistance

Cross-sectional area of the conductor mm²	XLPE and HFD1				HFD2					
	Voltage rating				*Voltage rating*					
	600/1000 V		*1900/3300 V*		*600 / 1 000 V*			*1 900 / 3 300 V*		
	Thickness of insulation mm		*Thickness of Insulation mm*		*Thickness of insulation mm*		*Insulation resistance[a] at 23 °C*	*Thickness of insulation mm*		*Insulation resistance[a] at 23 °C*
	Nom.	*Min.*	*Nom.*	*Min.*	*Nom.*	*Min.*	*MÙ·km, min.*	*Nom.*	*Min.*	*MÙ·km, Min.*
1.0	0.7	0.53	—	—	0.9	0.71	15	—	—	—
1.5	0.7	0.53	—	—	0.9	0.71	13	—	—	—
2.5	0.7	0.53	—	—	1.0	0.80	12	—	—	—
4	0.7	0.53	—	—	1.1	0.89	11	—	—	—
6	0.7	0.53	—	—	1.1	0.89	9	—	—	—
6	0.7	0.53	—	—	1.1	0.89	9	—	—	—
10	0.7	0.53	2.0	1.70	1.2	0.98	8	2.2	1.88	13
16	0.7	0.53	2.0	1.70	1.2	0.98	7	2.2	1.88	11
25	0.9	0.71	2.0	1.70	1.3	1.07	6	2.2	1.88	9
35	0.9	0.71	2.0	1.70	1.3	1.07	5	2.2	1.88	8
50	1.0	0.80	2.0	1.70	1.4	1.16	5	2.2	1.88	7
70	1.1	0.89	2.0	1.70	1.4	1.16	4	2.2	1.88	6
95	1.1	0.89	2.0	1.70	1.6	1.34	4	2.2	1.88	5
120	1.2	0.98	2.0	1.70	1.6	1.34	4	2.2	1.88	4
150	1.4	1.16	2.0	1.70	1.8	1.52	4	2.2	1.88	4
185	1.6	1.34	2.0	1.70	2.0	1.70	4	2.2	1.88	4
240	1.7	1.43	2.0	1.70	2.2	1.88	4	2.2	1.88	4
280	1.8	1.52	2.0	1.70	2.3	1.97	4	2.3	1.97	4
300	1.8	1.52	2.0	1.70	2.4	2.06	4	2.4	2.06	4
380	2.0	1.70	2.0	1.70	2.5	2.15	3	2.5	2.15	3
400	2.0	1.70	2.0	1.70	2.6	2.24	3	2.6	2.24	3
480	2.2	1.88	2.2	1.88	2.7	2.33	3	2.7	2.33	3
500	2.2	1.88	2.2	1.88	2.8	2.42	3	2.8	2.42	3
600	2.4	2.06	2.4	2.06	2.8	2.42	3	2.8	2.42	3
630	2.4	2.06	2.4	2.06	2.8	2.42	3	2.8	2.42	3
740	2.5	2.15	2.5	2.15	2.8	2.42	3	2.8	2.42	3
800	2.6	2.24	2.6	2.24	2.8	2.42	3	2.8	2.42	3
960	2.7	2.33	2.7	2.33	2.9	2.51	3	2.9	2.51	3
1000	2.8	2.42	2.8	2.42	3.0	2.60	3	3.0	2.60	3
1200	2.9	2.51	2.9	2.51	3.2	2.78	3	3.2	2.78	3

[a] Based on a minimum volume resistivity of 1.0 x 1011 Ù.m at 23 °C and the nominal thickness of the dielectric.

Note. The minimum insulation resistance of both XLPE and HFD1 insulation shall be at least 100 MÙ″ km at 23 ºC.

Table 10 — Bedding and Wire Armour of Cables Without Lead Sheath

Nominal diameter over core or laid up cores mm		*Thickness of extruded bedding mm*		*Nominal [a] diameter of armour wire*
		Nominal	*Min.*	*mm*
	≤ 10	0.8	0.58	0.9[b]
> 10	≤ 15	0.8	0.58	0.9[b]
> 15	≤ 20	1.2	0.92	1.60[c]
> 20	≤ 25	1.2	0.92	1.60
> 25	≤ 35	1.4	1.09	2.0
> 35	≤ 55	1.6	1.26	2.5
> 45	≤ 60	1.6	1.26	2.5
	> 60	1.6	1.26	3.15

[a] Larger diameter wires may be used if agreed with the purchaser.

[b] Armour wires may be of diameter 0.9 mm or 1.25 mm.

[c] Armour wires may be of diameter 1.25 mm or 1.60 mm.

Table 11 — Bedding and Wire Armour of Cables with Lead Sheath

Nominal diameter over core or laid up cores mm		*Thickness of extruded bedding mm*		*Nominal diameter of armour wire[a] mm*
		Nominal	*Min.*	
	≤ 20	1.4	1.09	1.6
> 20	≤ 25	1.6	1.26	2.0
> 25	≤ 30	2.0	1.60	2.0
> 30	≤ 40	2.2	1.77	2.0
> 40	≤ 45	2.4	1.94	2.5
> 45	≤ 50	2.4	1.94	2.5
> 50	≤ 60	2.6	2.11	3.15
	> 60	2.6	2.11	3.15

[a] Larger diameter wires may be used if agreed with the purchaser.

Table 12 — Permissible Materials

(See ZS 756-4 and ZS 756-5)

Insulation	*Bedding*	*Sheath*	*Max conductor operating temperature*
XLPE	HFB1	HFS1 / HFS2	90 ºC
HFD1	HFB1	HFS1 / HFS2	90 ºC
HFD2	HFB / HFB1	HFS1 / HFS2	70 ºC

SECOND SCHEDULE

(Paragraph 3)

1.	ZS 688 Part 1	General Cables
2.	ZS 688 Part 2	Wiring Cables
3.	ZS 688 Part 3	PVC Distribution Cables
4.	ZS 688 Part 4	XLPE Distribution Cables
5.	ZS 688 Part 5	Halogen-free Distribution Cables

E. CHENDA,
Minister of Commerce, Trade and Industry

LUSAKA
13th June, 2013
[MST/52/2/11C]