

## 1- PURPOSE

The purpose of this document is a proposal to calculate the cable size considering load current, for ITRC data centre.

## 2- STANDARDS AND CODES

IEC 287	Calculations of the continuous current rating of cables
IEC 364-5-523	Electrical installation in buildings – Current-carrying capacities
IEC 60228	Conductors of insulated cables.
IEC 60885	Electrical test methods for electric cables.
IEC 60332	Test on electrical cables under fire condition.
IEC 60754	Test on gases evolved during combustion electric cables.

## 3- GENERAL ELECTRICAL DATA

### 3.1 Electrical system voltages

20kV, 50 Hz, 3 phase,

400V, 50 Hz, 3 phase, High resistance grounded. Fault current limited to 10A

230V, 50 Hz, 1 phase, High resistance grounded. Fault current limited to 10A

3.2 Earthing fault protection : Yes

3.3 Voltage drop : Refer section 4.4.

### 3.4 Cables in parallel

Where two or more cables are connected in parallel in the same phase or pole of the system, measures shall be taken to ensure that the load current is shared equally between them.

### Cable type

#### 3.5.1 Insulation for power cables shall be:

Cross-linked polyethylene (XLPE) or ethylene propylene rubber (EPR) for HV cables

#### 3.5.2 Conductor

- ◆ Conductor shall be stranded. Conductor shall be class 2 for cables for fixed installations and class 2 for flexible cables feeding mobile equipment.

- ◆ Cable cores shall be in copper.

### 3.5.3 Sheath

Cross linked polyethylene

## 4- BASIS OF CALCULATION

### 4.1 Basis

A cable selection shall be carried out with respect to the most stringent of the following criterion.

- ◆ Admissible steady state cable insulation thermal withstand
- ◆ Admissible voltage drop (steady state)
- ◆ Admissible over current in cable (short-circuit, overload)

### 4.2 Reference admissible current carrying capacities

For XLPE or EPR core insulation, maximum core temperature is 90°C and the current carrying capacities are the following:

#### 4.2.1 LV cables current carrying capacities

(Refer attachment #1)

### 4.3 Admissible current carrying capacities

#### 4.3.1 Rating factor for ambient temperature

- ◆ Ambient air temperature for this project project is 30°C.  
 $K_{AT} = 0.94$  Refer attachment #3)

#### 4.3.2 Group rating factor (Influence between cables)

- ◆ For cables installed in free air :
  - MV cables (20kV)  
Table 52-E4 of IEC 364-5-523, installation method L – 1 ladder with vertical spacing between ladder of 300 mm - over 9 touching cables in single layer formation on each cable ladder. (Attachment #6)  
 $K_{HA} = 0.80$
  - LV cables (0.4kV)  
Table 52-E4 of IEC 364-5-523, installation method L – 2 ladders with vertical spacing between ladder of 300 mm - over 9 touching cables in single layer formation on each cable ladder. (Attachment #6)  
 $K_{LA} = 0.75$

Overall admissible ampacity correction factors

#### 4.3.3.1 LV cables (0.4kV)

- ◆ For LV motors & power feeders installed on cable ladder

-  $K = K_{AT} \times K_{LA} = 0.94 \times 0.75 = 0.7$

4.4 Admissible voltage drop

4.4.1 Voltage drop calculation formula

The voltage drop is calculated from the following formula;

- Single-phase voltage drop :  $V_{drop} = 2 \times L \times I (R_a \cos\theta + X \sin\theta)$
- Three-phase voltage drop :  $V_{drop} = \sqrt{3} \times L \times I (R_a \cos\theta + X \sin\theta)$
- Motor start voltage drop :  $V_{drop} = \sqrt{3} \times L \times I_{LRC} (R_a \cos\theta_{LRC} + X \sin\theta_{LRC})$

where

- L = feeder length in km
- R<sub>c</sub> = conductor resistance of cable in D.C. at 90°C(ohm/km)
- R<sub>a</sub> = conductor resistance of cable in A.C. at 90°C(ohm/km)
- X = core inductance (ohm/km)
- I = rated current of electrical consumer to be connected (A)
- I<sub>LRC</sub> = Locked rotor current (A)
- cosθ = power factor of electrical consumer to be connected
- cosθ<sub>LRC</sub> = L.R.C power factor

For R and X values, refer to Attachment #9

Voltage drop limitation considered are as follows.

Feeder	Voltage Drop
From main switchboards to consumers during normal operation	5 %
Motor cables at full load	5 %
Motor cables from switchgears to motor terminal during starting	15 %
Lighting and small power cables (including AC, DC UPS circuits) between secondary panel and the furthest lighting fixture/small load.	2%
When secondary panel is located in unit	3 %

When secondary panel is located near the main distribution panel in substation	5 %
AC, DC Uninterruptible power supplies main power cables between batteries and main equipment cubicles	1 %

### Short-circuit current

The minimum conductor size for short circuit current is calculated as follows as per clause 434-03-03 of IEE WIRING REGULATION 16<sup>th</sup> edition 1991.

$$S = \frac{\sqrt{t} \times I}{k}$$

S = nominal cross sectional area of conductor in mm<sup>2</sup>

I = The value of short circuit current in amperes, expressed for a.c. as the r.m.s value.

k = 143 for HV cables insulated with XLPE

t = duration of short circuit (sec)  
0.25 sec (12.5 cycle) for HV circuits

Note 1. 0.25 sec (12.5 cycle) for HV circuit is based on the following fault clearing time.

Breaker	:	5 cycle (0.1 sec)
Instantaneous relay	:	1 cycle (0.02 sec)
Safety margin	:	6.5 cycle (0.13 sec)

### Attachment # 1

#### LV cable current carrying capacities

Nominal conductor cross-section (sq.mm)	Multi-core cables			
	In free air <sup>(1)</sup>		Underground <sup>(2)</sup>	
	2 cores	3 cores	2 cores	3 cores
1.5	26	23	26	22
2.5	36	32	34	29
4	49	42	44	37
6	63	54	56	46
10	86	75	73	61

16	115	100	95	79
25	149	127	121	101
35	185	157	146	122
50	225	192	173	144
70	289	246	213	178
95	352	298	252	211
120	410	346	287	240
150	473	399	324	271
185	542	456	363	304
240	641	538	419	351
300	741	620	474	396

- Note (1): Reference air temperature 30°C  
Reference installation Chart 52-C11 column E of IEC 364-5-523,  
with two loaded cores & three loaded cores
- (2): Reference soil temperature 20°C  
Reference thermal soil resistivity 2.5 K.m/W  
Reference installation Chart 52-C2 column D for two loaded  
conductors & Chart 52-C4 Column D of IEC  
364-5-523 for three loaded conductors.

Attachment # 2

**MV cable current carrying capacities**

Nominal Cross-section (sq.mm)	Allowable current(A) <sup>(1)</sup>	
	Direct laid in ground	Installed in free air on cable trays
3C-35	190	190
3C-50	225	225
3C-70	275	280
3C-95	330	340
3C-120	370	385
3C-150	420	445
3C-185	470	510
3C-240	540	590
1C-300	630	740

Note (1): Reference soil temperature 20°C  
Reference air temperature 30°C  
Reference thermal soil resistivity 1 K.m/W

Attachment # 3

**Correction factors for ambient air temperature other than 30°C**

(Table 52-D1 of IEC 364-5-523)

Ambient temperature (°C)	Insulation			
	PVC	XLPE and EPR	Mineral *	
			PVC covered or bare and exposed to loads 70°C	Bare not exposed to touch 105°C
10	1.22	1.15	1.26	1.14
15	1.17	1.12	1.20	1.11
20	1.12	1.08	1.14	1.07
25	1.06	1.04	1.07	1.04
35	0.94	0.96	0.93	0.96
40	0.87	0.91	0.85	0.92
45	0.79	0.87	0.87	0.88
50	0.71	0.82	0.67	0.84
55	0.61	0.76	0.57	0.80
60	0.5	0.71	0.45	0.75
65	-	0.65	-	0.70
70	-	0.58	-	0.65
75	-	0.50	-	0.60
80	-	0.41	-	0.54
85	-	-	-	0.47
90	-	-	-	0.40
95	-	-	-	0.32

\* For higher ambient temperatures, consult manufacturer

Attachment # 4

**Correction factors for ambient ground temperatures other than 20°C.**

(Table 52-D2 of IEC 364-5-523)

Ground temperature (°C)	Insulation	
	PVC	XLPE and EPR
10	1.10	1.07
15	1.05	1.04
25	0.95	0.96
30	0.89	0.93
35	0.84	0.89
40	0.77	0.85
45	0.71	0.80
50	0.63	0.76
55	0.55	0.71
60	0.45	0.65
65	-	0.60
70	-	0.53
75	-	0.46
80	-	0.38

Attachment # 5

**Rating factor for Soil thermal resistivity**

(Table 52 GJ of NFC 15-100)

Ground Thermal Resistivity (K.m/W)	Correction	Humidity	Soil		
0.50	1.21	Very wet soil	Sand	Clay and limestone	
0.70	1.13	Wet soil			
0.85	1.05	Normal			
1.00	1	Dry soil			
1.20	0.94	Very dry soil			Ashes and Slag
1.50	0.86				
2.00	0.76				
2.50	0.70				

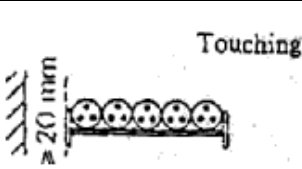
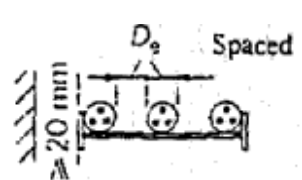


3.00	0.65				
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Attachment #6

**Correction factors for groups of more than one multicore cable**

(Table 52-E4 of IEC364-5-523)

Installation method In Table 52-B2			Number of cables						
			Number of Trays	1	2	3	4	6	9
Ladder supports, cleats, etc.	 <p>Touching</p>	1	1.00	0.85	0.80	0.80	0.80	0.80	
		2	1.00	0.85	0.80	0.80	0.75	0.75	
		3	1.00	0.85	0.80	0.75	0.75	0.70	
	 <p>Spaced</p>	1	1.00	1.00	1.00	1.00	1.00	-	
		2	1.00	1.00	1.00	0.95	0.95	-	
		3	1.00	1.00	0.95	0.95	0.95	-	

Attachment #7

**Correction factors for more than one circuit, cables laid directly in the ground**

(Table 52-E2 of IEC364-5-523)

Number of circuits	Cable to cable clearance				
	Nil (cables touching)	One cable diameter	0.125 m	0.25 m	0.5 m
2	0.75	0.80	0.85	0.90	0.90
3	0.65	0.60	0.75	0.80	0.85
4	0.6	0.60	0.70	0.75	0.80
5	0.55	0.55	0.65	0.70	0.80