GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

Pamphlet

SELECTION OF CONDUCTORS

IN LV INSTALLATIONS

END USER

GENERAL POWER SUPPLY SUPERVISORS

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EXCELLENCE IN MAINTENANCE

INDIAN RAILWAYS

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SELECTION OF CONDUCTOR

Selecting the correct type and size of cable/ conductor not only ensures the trouble free performance but also optimizes the cost of material, installation and the operation as well.

While selecting the correct type and size of the cable/ conductor, following procedure to be kept in mind.

SELECTION OF CONDUCTORS

- Detail of designed & type of load including capacity of protective Device .
- Minimum current carrying capacity of cable
- Applying reduction factor due to ambient temperature, installation method, grouping
- Checking of size of cable based on voltage drop
- Checking of size of cable for short circuit condition
- Selection of size of cable

DETAIL OF DESIGNED & TYPE OF LOAD INCLUDING CAPACITY OF PROTECTIVE DEVICE .

This may include details of connected load such as :-

(i) Single or three-phase (system Voltage)

(ii) Type of Load

(iii) Rating of MCB or other protective Device

• System Voltage

Important factors to be considered are rated voltage, maximum operating voltage whether dc or ac, number of phases and frequency. This is the rated voltage of the system, in which the cable is to be installed & used.

Minimum Current Carrying Capacity of Cable

(Ref: Para 4.1.3.6 & 5.2.7 of IS 732:2019)

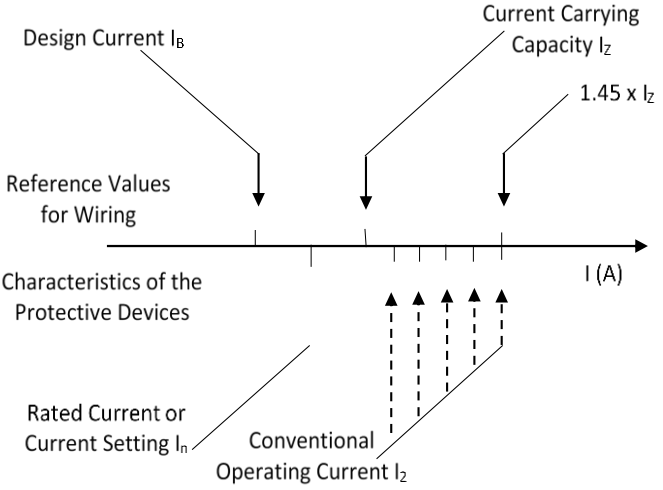
After deriving the capacity of MCB for the particular load, the selection of adequate size of the conductor is very important. The operating characteristics of a device protecting a cable/wire against overload shall satisfy the two following conditions: -

This is applicable for variable load.

$I_B \leq I_n \leq I_Z$ (Equation 1)

$I_2 \leq 1.45x\ I_Z$ (Equation 2)

These equations can be also explain as per given diagram



Where;

Illustration of equations 1 & 2 for Selection of Cable

I_B	**The design current for that circuit**
I_Z	The continuous current-carrying capacity of the cable/wire
I_n	The rated current of Protective device (NOTE: For adjustable protective devices, the rated current I_n is the current setting selected.
I_2	The current ensuring effective operation in the conventional time of the protective device i.e. 1.45x I_B
	Conventional time: -The conventional time is 1 h for circuit-breakers of rated current up to and including 63 A, and 2 h for circuit-breakers of rated current above 63 A.

Applying reduction factor due to ambient temperature, installation method, grouping

The current-carrying capacity of a conductor/cable depends upon the different parameters like Size/type of core/type of insulation further it also depends upon other factors given below: -

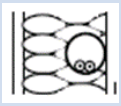
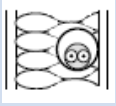
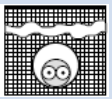
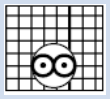
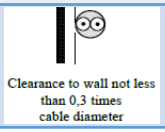
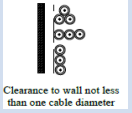
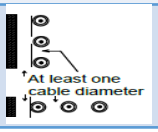
i. The method of installation of Conductor
ii. The ambient temperature
iii. Group containing more than one circuit

Detail of all above factor is required for deriving the correct size of conductor

Method of Installation of Conductor

(Ref: Para 4.1.3.6 & 5.2.7 of IS 732:2019)

Wiring/cabling is done in 73 different installation methods given under Table 19 of IS 732:2019, these methods of installation has been further classified under 10 groups (A1,A2,B1,B2,C,D1,D2,E,F & G) given in Table 20 of IS 732:2019 for obtaining current carrying capacity of different installations.

A1	A2	B1	B2	C	D1	D2
						
E			F		G	
						

Based on methods as shown the current carrying capacity of different size/core/ PVC & XLPE insulation type of conductors are given in table 21 to table 24, table 29 to table 32 of IS 732:2019. ANNEX T of IS 732:2019 is a simplified version of above tables as shown below with reference ambient temperatures.

a) For insulated conductors and cables in air, irrespective of the method of installation: 30 °C; and
b) For buried cables, either directly in the soil or in ducts in the ground: 20 °C

The Ambient Temperature

(Ref: Para 5.2.5.1 of IS 732:2019)

The ambient temperature is the temperature of the surrounding medium when the cable(s) or insulated conductor(s) under consideration are not loaded. Current carrying capacity of conductor also depends on the ambient temperature.

While selecting the type of insulation of the conductor for a particular location, it should be ensured that the ambient temperature in that area under normal operation and fault conditions should not exceed the limiting temperature of the insulation, which is given Table 8 of IS 732:2019

Where the ambient temperature in the intended location of the insulated conductors or cables differs from the reference ambient temperature (30 °C for Air & 20 °C for buried in ground), the appropriate correction factor given in Table 33 and 34 of IS 732:2019 shall be applied to the values of current-carrying capacity set out in ANNEX T of IS 732:2019

Ambient temperature for conductor or cables should be taken for particular location of the installation not the ambient temperature of the environment.

Group containing more than one circuit

(Ref: Para 5.2.6.5of IS 732:2019)

The group reduction factors (Table 36 to 40 of IS 732:2019), are applicable to groups of insulated conductors or cables having the same maximum operating temperature i.e. 70°C

The current-carrying capacities given in ANNEX T of IS 732:2019 related to single circuits for single phase/three phase PVC/XLPE conductor in different installation (A1, A2, B1, B2, C, D1, D2, E & F).

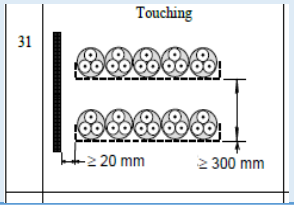
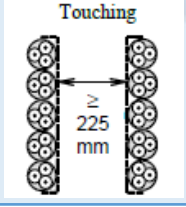
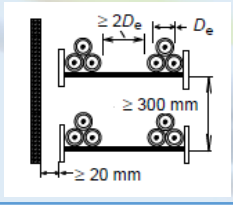
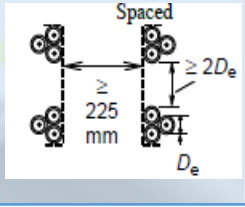
Where more insulated conductors or cables, other than bare mineral insulated cables not exposed to touch, are installed in the same group, the group reduction factors specified in tables 36 to table 38 of IS 732:2019 shall be applied.

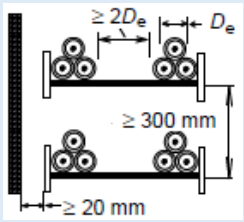
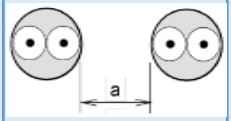
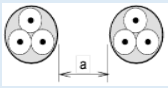
Similarly, the current-carrying capacities given in ANNEX T of IS 732:2019 also related to single circuits for single phase/three phase conductor in different installation (E & F).

If, due to known operating conditions, a cable or insulated conductor is expected to carry a current not greater than 30 percent of its grouped current-carrying capacity, it may be ignored for the purpose of obtaining the reduction factor for the rest of the group.

Where more insulated conductors or cables are installed in the same group, the group reduction factors specified in tables 39 to table 40 of IS 732:2019 shall be applied.

For groups containing cables or insulated conductors having different maximum operating temperatures, the current-carrying capacity of all the cables or insulated conductors in the group shall be based on the lowest maximum operating temperature of any cable in the group, together with the appropriate group reduction factor.

Perforated cable tray systems (vertical spacing between cable trays of 300 mm and at least 20 mm between cable trays)	Vertical perforated cable tray systems (for horizontal spacing between cable trays of 225 mm)	Perforated cable tray systems (for vertical spacing between cable trays of 300 mm and at least 20 mm between cable trays)	Vertical perforated cable tray systems (for horizontal spacing between cable trays of 225 mm)
			

Cable ladder systems, cleats(for vertical spacing between cable trays of 300 mm and at least 20 mm between cable trays)	Multi-core cables		Single-core cables
			

Guidelines to Use Tables to Assess Required Current Carrying Capacity

All above factors affect the current carrying capacity of wiring system. Permutations and combinations of all the above factors are required to estimate the required current carrying capacity of the particular cross-section of the conductor. Guideline/method for accessing the current carrying capacity of the particular cross-section of the conductor are as below.

Procedure for Deriving Current Carrying Capacity of Wire through an Ex.

Step	Procedure
1.	Decide type of wiring – surface / flush to the surface / concealed / underground / in air Check situation – walls (masonry / wooden,/ insulated), flooring (masonry / raised), ceiling, ducts, shafts, voids, ground where wiring is to be installed
2.	Check table19 of IS732:2019, under which Reference Method of Installation
3.	Decide type of Insulation of conductor PVC / XLPE/ EPR / Mineral
4.	Decide type of Core
5.	Check Current carrying capacity of conductor for particular size/core/insulation from Annex-T of IS 732:2019
6.	Apply ambient temperature reduction factor from table-33 of IS 732:2019
7.	Apply reduction factor depending on the number of circuits from tables 36 to 39 of IS 732:2019

Above procedure can be explain by taking an example as given below:

Example: 2 core 2.5 Sq.mm PVC insulated copper wires to be laid in B-1 installation (through conduit in wall (masonry)). Ambient temperature 40°C is considered. What will be current carrying capacity of wire after applying all above factors?

Guidelines to use Tables to assess required Current Carrying Capacity

Step	Steps	Example	Remarks
1		2 core 2.5 Sq.mm pvc insulated copper Wires to be laid in B-1 installation	
2	Method of Installation	B1 Installation	B1 Installation (S.N.59 of table-19 of IS: 732 2019) is a commonly used wiring system in which Insulated conductors or single-core cables to be laid in conduit in masonry of building.
3	Type of Insulation	PVC insulated	
4	Type of Core	Two core	
5	Checking of Current carrying capacity of conductor	23 Amp.	As per Annex-T of IS 732:2019, Current carrying capacity of wire in B-1 installation for two core 2.5 Sq.mm PVC insulated copper wiring is 23 Amps.
6	Applying reduction factor for Ambient temperature	0.87 = 23x0.87 = 20.01 Amp.	Ambient temperature 40°C to be considered. As per table-33 of IS 732:2019, reduction factor 0.87 will be applicable.
7	Applying reduction factor for grouping	Reduction Factor= 0.70 Current carrying capacity will be reduced 20.01x0.70= 14 Amp.	3 No. circuits with 2 core wire are also laid in same conduit. As per table-36 of IS 732:2019, reduction factor 0.70 will be applicable.

As per table, it is clear that current carrying capacity of 2 core 2.5 sq.mm PVC insulated copper wire (Original current carrying capacity of 23 Amp) in B-1 installation, Ambient temp 40°C, laid with additional 2 Nos. same wire in same conduit is reduced to 14Amp.Hence during the installation of conductors all the above factor should be considered.

- ## Voltage Drop due to Length of Conductor

Voltage drop between the origin of the consumer's installation and the equipment should not be greater than that given in table below:

	Type of Installation	Lighting %	Other Uses %
1	Low voltage installations supplied directly from a public low voltage distribution system	3	5
2	Low voltage installation supplied from private LV supply	6	8

Calculation of Voltage Drop

(Ref: Annex Y of IS 732:2019)

Voltage drops may be determined using the formula:

$$u = b\left(\rho_1 \frac{L}{S}\cos\varphi + \lambda L \sin\varphi\right) I_B$$

Where

u	**=**	**Voltage drop in V**
b	=	Coefficient equal to 1 for three phase circuit, and to 2 for single phase circuits.
ρ_1	=	Resistivity of conductors in normal service, 0.0225 $\Omega mm^2/m$ for copper and 0.036 $\Omega mm^2/m$ for aluminium
L	=	The straight length of the wiring systems, in m
S	=	The cross-sectional area of conductors, in mm^2
Cos ϕ	=	The power factor, in the absence of precise details, the power factor is taken as equal to 0.8 (sin ϕ =0.6)
λ	=	The reactance per unit length of conductors
I_B	=	Design current (in amps)

Note:-Voltage drop per meter of cable is also given by manufacturer.

Short Circuit Current Withstand

After applying all the above factors, the size of the cable may be finalized. It may be checked that this cable may bear the fault current in case of short circuit.. Any cable's short time current withstand capacity can be calculated using the following formula:

$$S = [(I \sqrt{t}) / K]$$

Where, I = Short Circuit Current, in Amperes,
t = Duration of Short Circuit, in seconds,

K = Adiabatic Constant (= 115 for PVC /Copper, = 143 for XLPE/ Copper, = 76 for PVC / Aluminium and = 92 for XLPE / Aluminium)

Disclaimer:

It is clarified that this pamphlet does not supersede any existing provisions laid down by Indian Standards, Railway Board, RDSO or Zonal Railways. The pamphlet is for guidance only and it is not a statutory document.

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