Guidelines for laying wiring in energy chains

Great care must be taken when laying wiring in energy chains.

As a matter of principle the following points should be adhered to:

1. The wires should be laid individually, loosely beside one another, insofar as this is possible. If wires of different diameters are being laid on top of each other or beside each other then the it is recommended to use separating stays.

2. Permanently flexible wiring with an outer diameter < 10 mm, with which a separation using stays is not possible, should be gathered loosely together, arranged in a flexible conduit and laid in the energy supply chain. The diameter of the flexible conduit selected should be substantially larger than the sum of the individual cable diameters.

3. The wires must be able to move freely in the frame stays. For safety, 10% of the wiring diameter should be provided as free space.

4. It is necessary to carefully ensure that the wiring can pass through the curve radii without any constraint. Also with multi-layer laying the wires must have sufficient free space between one another through the curve radii.

5. The wires must be laid in the energy chain in such a way that they are not contorted (no twists). Therefore the wires must be unrolled from the drum or ring before laying (do not lift wires off in coils).

6. The weight distribution in the chain or in the chain stays should be symmetrical as far as possible. Heavy wires should be laid outwards, lighter supply lines towards the centre.

7. All wires must be strain-relieved at anchoring points and attachments. In doing so it must be ensured that the pressure on the outer sheath is spread over a large surface area. The clamping must be carried out carefully such that the cores in the wires are not crushed and yet that the wires are no longer able to slide.

8. In principle, only permanently flexible wiring should be used. It is essential to comply with the permitted bend radii.

9. When installing and laying energy chains the following standards (amongst others) must be complied with:

DIN VDE 0100
DIN VDE 0113

Instructions for transportation, storage and laying of category 5, category 6 or category 7 data cables

The LAN cabling must be protected from damage and moisture ingress.
This includes:

- Careful transportation (do not expose cable reel to any shock loading).
- Proper storage
- Provide end caps for ends
- Comply with storage and laying temperatures
- Checking the cable paths and preparing them for the wiring , i.e. smoothing, deburring, modifying bend radii etc. if necessary
- Use appropriate tools.
- Comply with permissible bend radii and draw forces (per corresponding table)
- Draw / reel cable off rotating reel (tangentially), never over the flange (head) or from the ring, in order to minimise torsion damage.
- Attach pressure relief devices (props) rather than having the coverings in direct contact with the cables.
- With flat wiring the bending is to be carried out on the small diameter.
- In order to comply with the EMC requirements (EN 55022) it is necessary to connect the screens all the way through.

Permissible Bending Radii for Laying on 20°C (+/-10°C)

for harmonized wires acc. HD 516 S2:1997 + A1:2003 (DIN VDE 0298-300)

Wires for fixed installation (HD21 / HD22)

Nominale voltage to 0,6 / 1kV	Cable diameter mm			
	D ≤ 8	8 < D ≤ 12	12 < D ≤ 20	D > 20
for standard application	4*D*	5*D*	6*D*	6*D*
for carefuly bending	2*D*	3*D*	4*D*	4*D*

Flexible Wires (HD21)

Nominale voltage to 0,6 / 1kV	Cable diameter mm			
	D ≤ 8	8 < D ≤ 12	12 < D ≤ 20	D > 20
fixed installation	3*D*	3*D*	4*D*	4*D*
freely moveable	5*D*	5*D*	6*D*	6*D*
at the entry to mobile devices and tools without mechanical load on the wiring	5*D*	5*D*	6*D*	6*D*
with mechanical load [1]	9*D*	9*D*	9*D*	10*D*
festooned as on a gantry crane	10*D*	10*D*	11*D*	12*D*
for repeated winding operations [1]	7*D*	7*D*	8*D*	8*D*
looped around via deflection pulley [1]	10*D*	10*D*	10*D*	10*D*
1) see 5.4.1 of this HD in connection with dynamic stress				

Flexible Wires (HD22)

Nominal voltage to 0,6 / 1kV	Cable diameter mm			
	D ≤ 8	8 < D ≤ 12	12 < D ≤ 20	D > 20
for fixed installations	3*D*	3*D*	4*D*	4*D*
free moveable	4*D*	4*D*	5*D*	6*D*
at the entry to mobile devices and tools without mechanical load on the wiring	4*D*	4*D*	5*D*	6*D*
with mechanical load [1]	6*D*	6*D*	6*D*	8*D*
festooned as on a gantry crane	6*D*	6*D*	6*D*	8*D*
for repeated winding operations [1]	6*D*	6*D*	6*D*	8*D*
looped around via deflection pulley [1]	6*D*	8*D*	8*D*	8*D*
1) see 5.4.1 of this HD in connection with dynamic stress				

Permissible Bending Radii for Laying on 20°C (+/-10°C) for not harmonized Wires (DIN VDE 0298-3)

Type	Nominal voltage to 0,6/1kV			Nom.voltage over 0,6/1kV
Wires for fixed installation	Overall Diameter of the cable or of a flat cable mm			
	up to 10	from 10 to 25	over 25	
for fixed installation	4*D*	4*D*	4*D*	6*D*
for forming	1*D*	2*D*	3*D*	4*D*

Type	Nominal voltage to 0,6/1kV				Nom.voltage over 0,6/1kV
For flexible applications	Overall Diameter of the cable or of a flat cable mm				
	up to 8	from 8 to 12	from 12 to 20	over 20	
for fixed installations	3*D*	3*D*	4*D*	4*D*	6*D*
in motion	3*D*	4*D*	5*D*	5*D*	10*D*
at entry	3*D*	4*D*	5*D*	5*D*	10*D*
for forced bendings [1] such as					
for reeling operation	5*D*	5*D*	5*D*	6*D*	12*D*
for cable trolley operation	3*D*	4*D*	5*D*	5*D*	10*D*
for cable chains	4*D*	4*D*	5*D*	5*D*	10*D*
for roller guidance system	7,5*D*	7,5*D*	7,5*D*	7,5*D*	15*D*

[1] The suitability for this operation must be ensured by special construction characteristics.

For energy cables

acc. HD 603 S1:1994/A2:2003 and HD 620 S1:1996 and HD 621 S1:1996

plastic insulated cables				paper insulated cables with lead sheath	
multicore		single-core		multicore	single-core
to 1 kV	**from 1 kV**	**to 1 kV**	**from 1 kV**		
12*D*	15*D*	15*D*	15*D*	15*D*	25*D*

D = overall diameter of the cable

For telecommunication cables and installation cables for telecommunications systems

Cable type	minimum bending radius in mm
Installation cable (e.g. FvYAY, FYAY, J-Y(ST)Y ect.)	7,5D
Telecommunication cable for earth laying (e.g. F-2YA2Y, A-2YF(L)2Y ect.)	10D
DA = overall diameter of the cable	

Permissible Laying Temperatures

When laying power cables the cable temperature should not fall below:

- Paper insulated cable + 5°C
- Plastic-insulated cable with PVC sheath + 5°C
- XLPE-insulated cable with PE sheath - 20°C

At lower temperatures the cables must be adequately warmed up beforehand. This can be done by storing them in a heated area (approx. 20°C) for several days or by means of special hot air equipment.

Permissible Pull-forces for Laying

When laying power cables by machine, particular attention must be paid to the permissible tensile forces:

Pulling method	Constuction of cables	Tensile force
pulling head on the conductor	all types of cables	F = A . 50 N/mm² (Cable with Cu- conductor) F = A . 30 N/mm² (Cable with Al- conductor)
with cable stocking	all wire-armoured cables (e.g. NYFGY, NAYFGY ect.)	F = K . D² (K=9 N/mm²)
	cables with metal sheath, without tension-proof armour (e.g. NKBA, NYKY, NAKLEY ect.)	F = K . D² (single-sheathed cable K=3 N/mm²)
	(e.g. NEKEBA, NAEKEBA ect.)	(3-core single lead sheath cable K=1 N/mm²)
	plastic cables without metal sheath, plastic cables without armour (e.g. NYY, NYSY, NYSEY, NYCWY, NA2XS2Y ect.)	F = A . 50 N/mm² (Cu-conductor) F = A . 30 N/mm² (aluminium conductor)

If three single-core cables are laid simultaneously with a common cable stocking, the same max. pulling forces as they are applicable for single-core cables, are valid. For 3 laid single-core cables the calculation of the permissible pulling forces is based on 3 cables, whereas it is based on 2 cables if the 3 single-core cable are not laid-up.

A = total conductor cross-section in mm² (without screen and concentric protective conductor)
D = outside diameter of cable in mm.