Fundamentals of Stranding Process

CabWire 2017 - Düsseldorf

Stranding

Stranding is helical twisting of several individual elements around an imaginary axis.

By stranding, the individual elements get a cohesion.

Above all stranding is necessary to make cables bendable and movable.

While bending the elements in the outer layer get elongated, the elements in the inner layer get compressed.

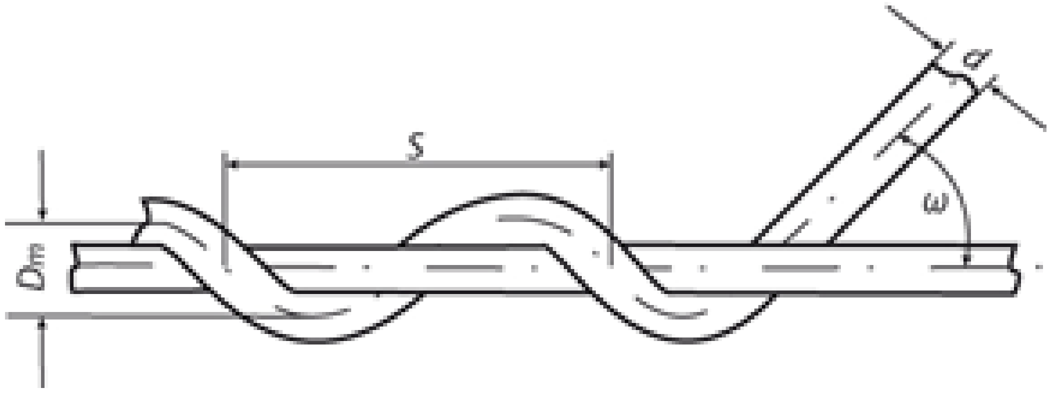
By stranding, the stranding elements are located alternatingly on the inner and on the outer side of the bend. The elements get elongated and compressed locally during the bend.

As the elements have the ability to move a little bit within the strand (depending on type), some of the stress due to the bending is reduced.

Basically the more often the elements are being twisted per meter, the more flexible a strand will be.

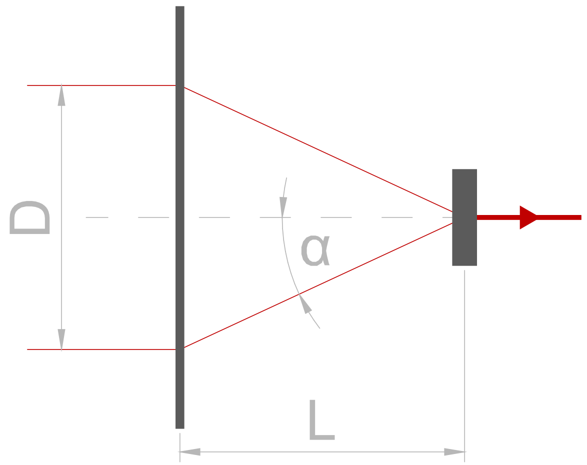
Basic concepts in stranding

d	Diameter of a single element in the strand
D_m	Average diameter of a stranded layer
D_i	Diameter below a stranding layer
f	Extension factor
L	Elongated length of the stranded element
l	Length of the strand
S	Lay length
z	Number of elements with the same diameter in a stranding layer
ω	Stranding angle



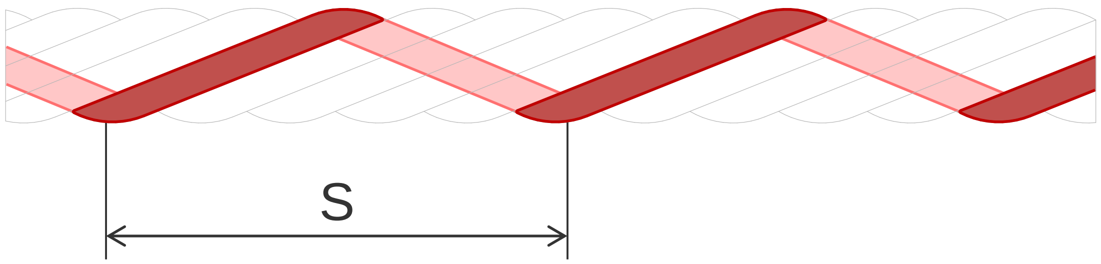
Stranding point

The stranding point is the point where all individual elements of a stranding layer come together and are being arranged within the strand



Lay length S

Also known as pitch, is the distance required to complete one revolution of a wire around the diameter of the conductor.



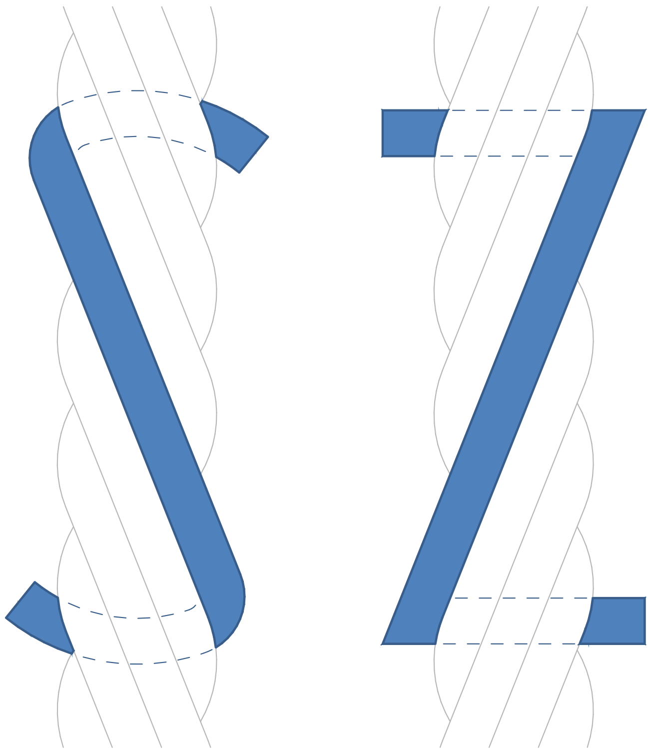
Long lay lengths do not allow right geometric pattern control of the stranded conductor.

Lay direction

The direction of the helix of a stranding layer is called lay direction.

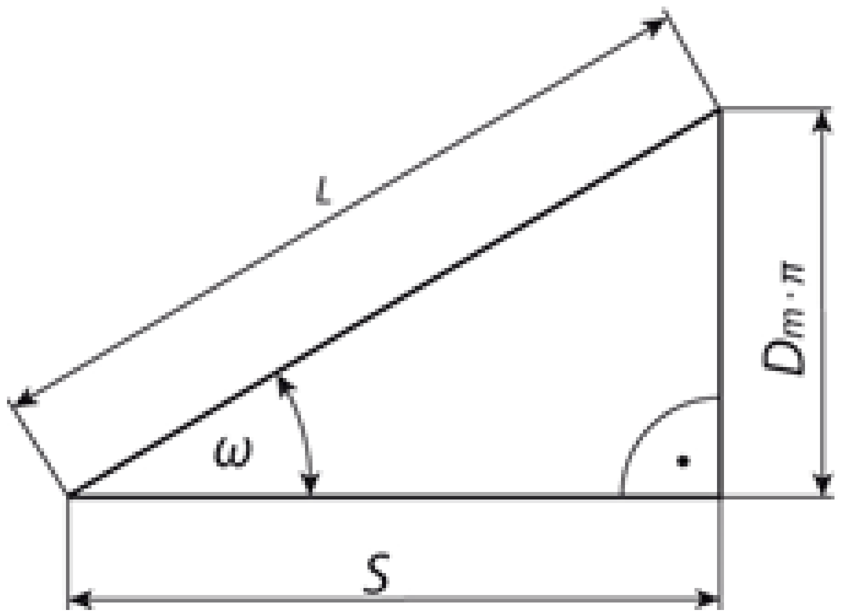
If the wires turn left leading away from the observer, it is an “S” lay direction.

If the wires turn right leading away from the observer, it is a “Z” lay direction.



Stranding angle ω

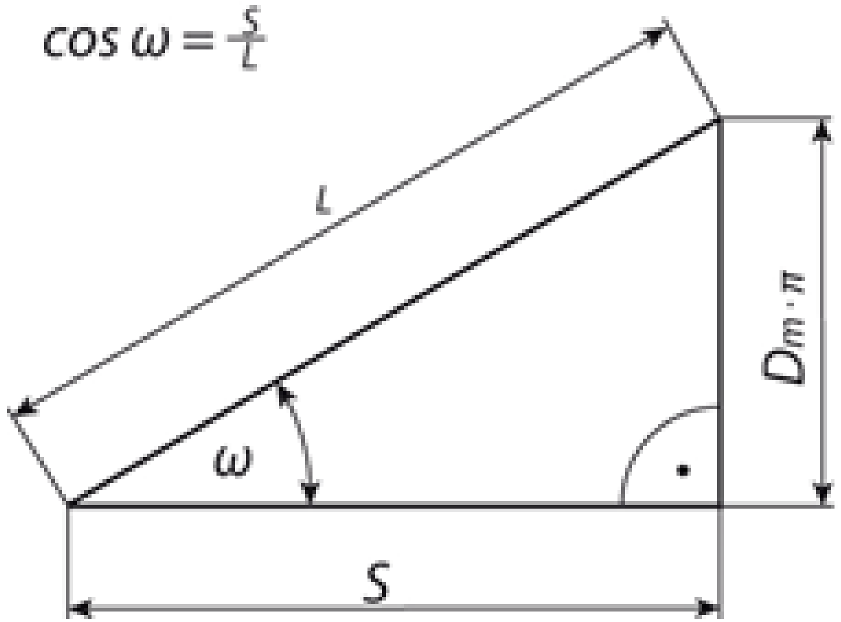
$$\tan\omega = \frac{D_m \cdot \pi}{S}$$



Elongation factor f

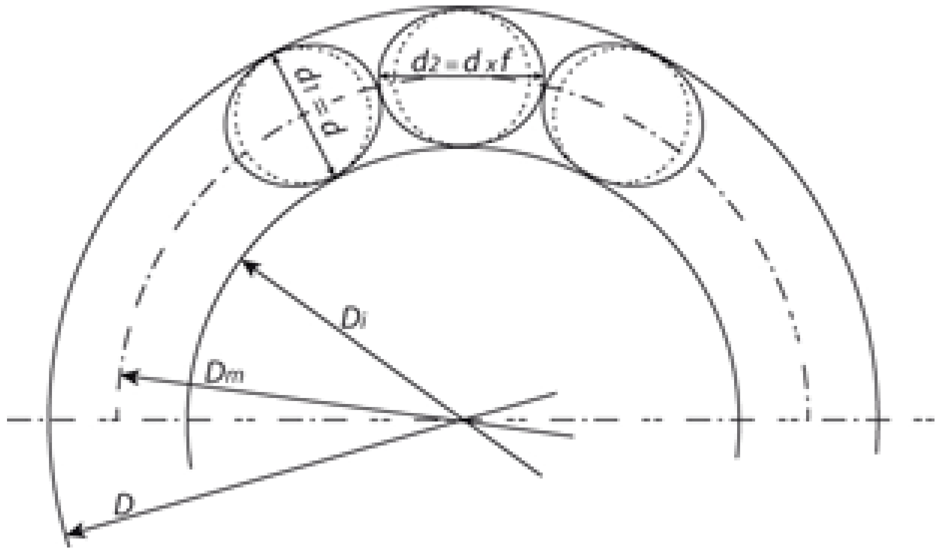
$$f = \frac{L}{l}$$

$$f = \frac{\sqrt{(D_m \cdot \pi)^2 + S^2}}{S}$$



Number of elements per layer z

$$z = \frac{D_m \cdot \pi}{d \cdot f}$$



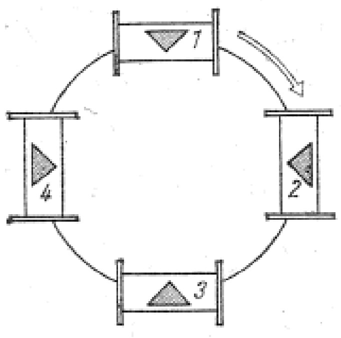
Backtwist

Within a simple strand the axis of each element rotates itself with the helical path of the strand.

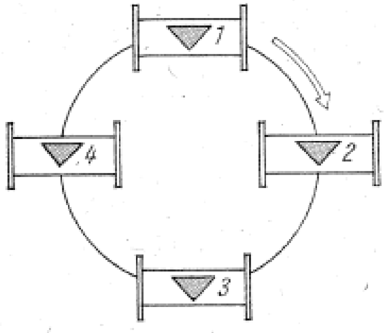
This creates torsional stress within each element and can lead to a damaged conductor or cable.

To avoid this backtwist is applied, meaning that the individual element keeps its original orientation within the strand (100% backtwist).

Backtwist of less than 100% can also be applied.



Orientation of payoff bobbins during one twist without backtwist



Orientation of payoff bobbins during one twist with 100% backtwist

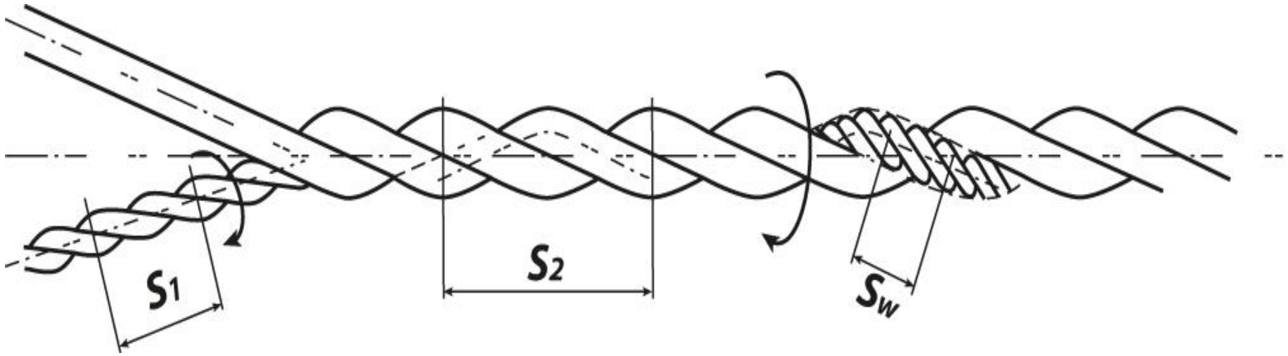
Effective lay length Sw

If a stranded element (conductor) is being stranded again in a second stranding step (cable), the final lay length of this element will change, unless the second stranding step is being done with 100% backtwist.

The effective lay length of the element can be calculated like

$$\frac{1}{S_w} = \frac{1}{S_1} \pm \frac{1}{S_2}$$

S_1	Lay length of the stranded element
S_2	Lay length of the strand layer
S_w	Effective lay length
f	Extension factor



Effective lay length

The calculation of the effective lay length will have to be done with positive sign (+) if both stranding steps have the same direction (S/S or Z/Z).

The calculation will have to be done with negative sign (-) if both stranding steps have alternating directions (S/Z or Z/S).

Due to the length reduction during the stranding process, the elongation factor f will also have to be taken in consideration.

$$\frac{1}{S_w} = \frac{1}{S_1} \pm \frac{1}{S_2 \cdot f}$$

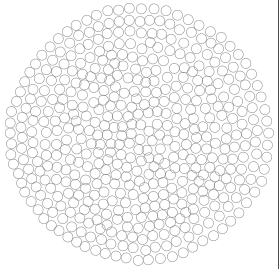
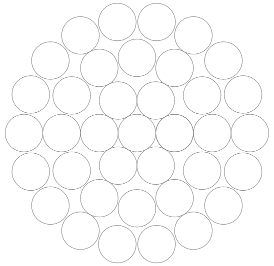
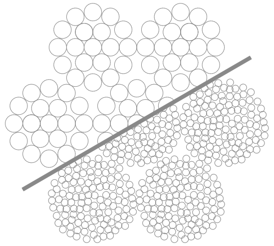
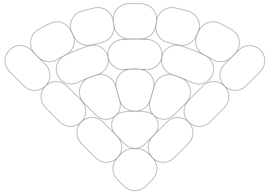
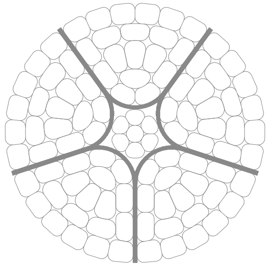
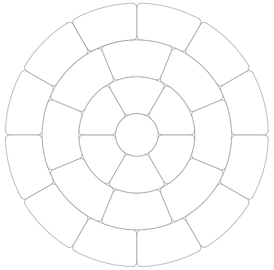
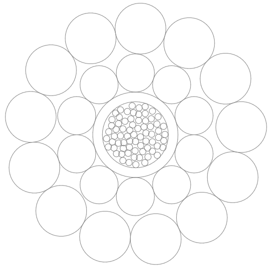
$$S_w = \frac{S_1 \cdot S_2 \cdot f}{S_2 \cdot f \pm S_1}$$

For strands produced on lines with backtwist less than 100%, the change of lay length due to the backtwist has to be taken into consideration.

Attention: Paying off a spool over flange already creates some backtwist!

Types of strands

Common types of strands

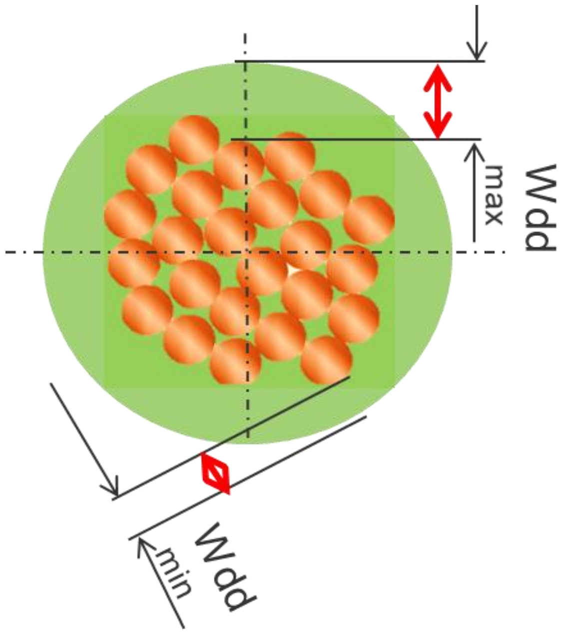
Bunched	Concentric	Rope	Sector	Segmental	Trapezoidal	Annular
						

Many other layouts for cables, special cables, etc… available.

Bunched strands

The most simple way to produce a strand is to take any number of elements / wires without any orientation and twist them.

- Cheap and flexible
- Simple process / simple equipment
- Any number of wires possible
- Poor roundness
- Uneven surface leading to thick insulation

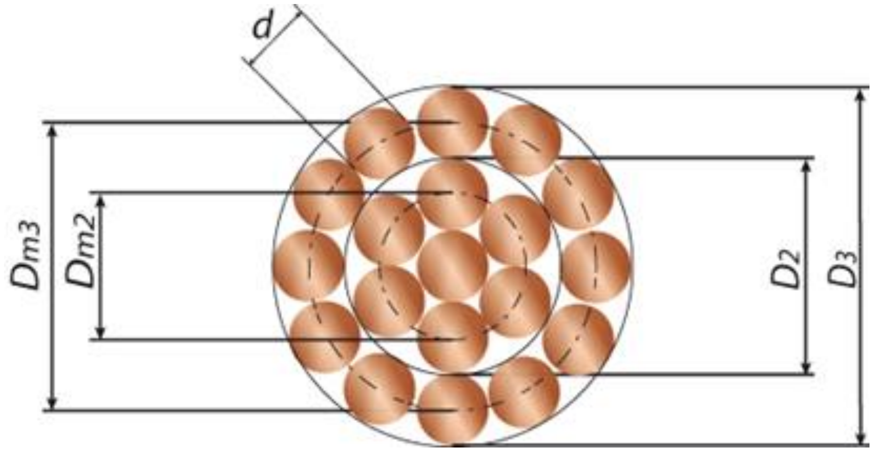


Concentric Strands

To produce strands with higher quality regarding roundness and concentricity, the elements / wires will have to be arranged in a geometrical order.

These strands are being called concentric, as all layers are being arranged concentric to the central axis.

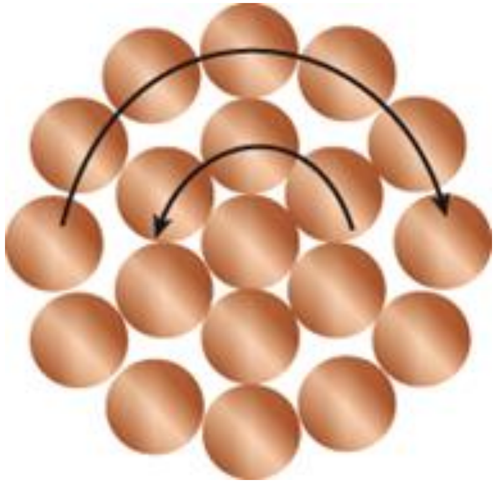
The standard formation for concentric strands is 1+6+12+18+24… wires.

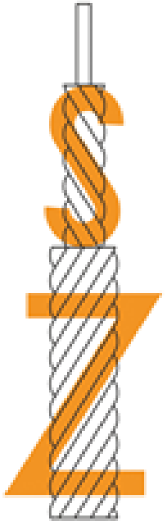


True Concentric Strands

Strands with alternating lay direction are being called True Concentric Strands. These strands have to be produced in several steps.

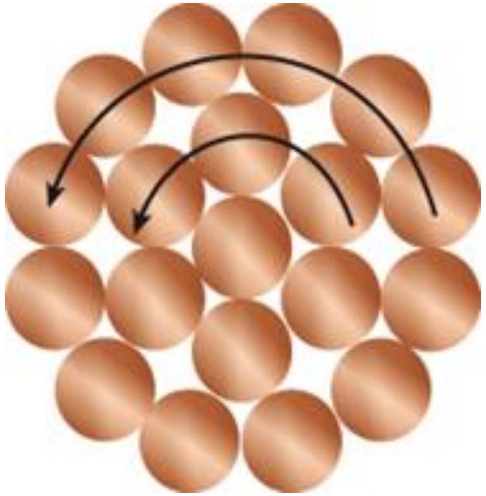
- Alternating lay direction
- Unequal or equal lay length





Unilay Strands

Strands with the same lay direction and lay length are being called Unilay Strands.



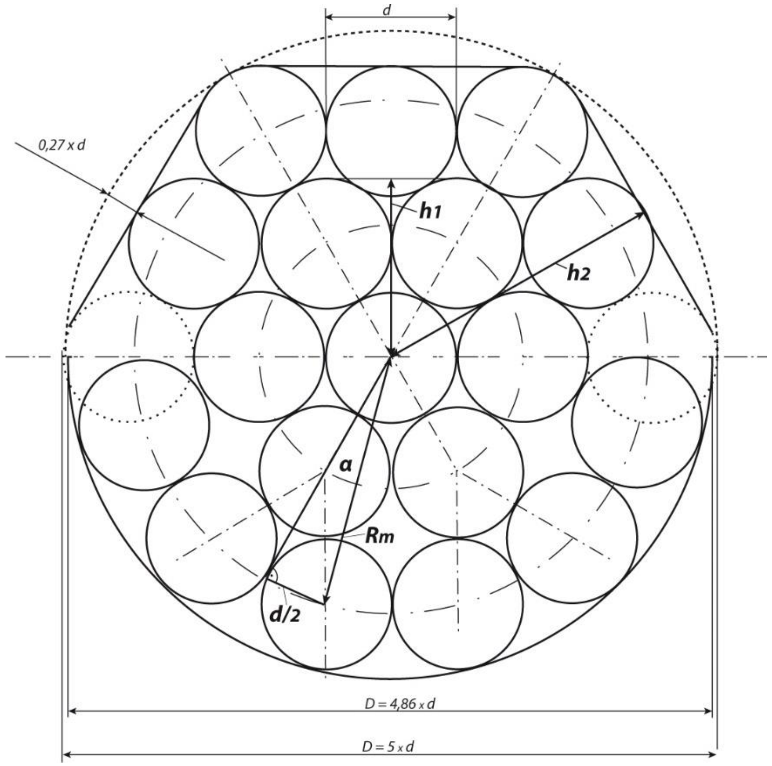
Unilay Strands can be produced in one production step, especially with doubletwist lines.

This makes them very efficient and wide spread within concentric strands.

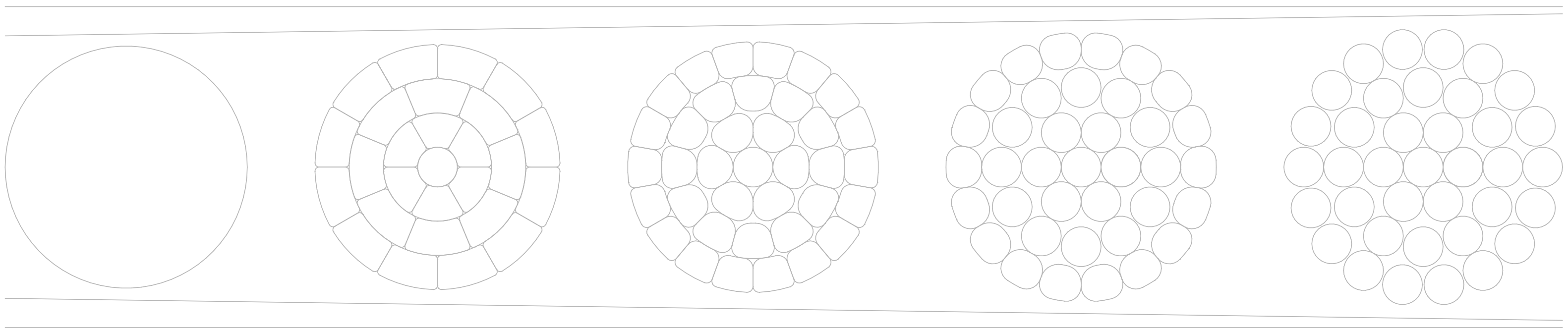
Compacted Unilay Strands

Unilay Strands over 7 wires can easily lose their geometric orientation and fall to a hexagon shape. Compacting is applied.

- Compacted concentric conductor reduces the diameter of the conductor up to 10%.
- Compressed concentric conductor reduces the diameter of the conductor by around 3%.



Filling Ratio



	Solid	Trapezoidal	Compacted	Compressed	Stranded
Diameter	6,1	6,2	6,3	6,8	7,0
Fill factor	100%	97%	93%	80%	75%
Ø increase	-	1,5%	3,7%	11,8%	15,5%

Thank you for your attention!

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