Universal Cable Handbook

EXCEL 3x10/10 mm^2
FXCEL 3x16/10 mm^2
AXCES 3x70/16 mm^2
AXCES 3x70/25 mm^2
AXCES 3x95/25 mm^2

Universal cables for use
in Ground
in Water
in Air

Handbook for realizing
transmission lines

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Suspension clamp ECH14

Ericsson
Universal Cable Handbook

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Content

Universal cable concept– a cost effective and safe solution

Traditionally electrical distribution has been divided between underground cables and overhead lines where underground cables have been dominating in urban areas and overhead lines in rural areas. With the Universal cable concept this pattern is changing with a new and cost effective way of electrical power distribution on 12 and 24 kV.

This new application is that one and the same cable is used all the way and the method of installation is chosen that is most suitable for each part of line. The methods of installation can be a mixture of undergrounding, say where ploughing is possible, in water and self supported overhead between poles, which ever is considered as the most cost effective. Separate cables to transformers and lightning arrestors are not required. In this way it is possible to optimise for both economy and security. A number of positive factors to take into consideration are:

- Greater freedom when choosing line routes.
- Universal use, i.e. underground, in water, on overhead poles.
- Together with LV and telecom.
- Lower service and running costs
- Lower maintenance costs
- Aesthetic appearance.
- Excellent safety aspects, i.e. fully insulated, screened.
- No electric field, low magnetic field.

As this gives a completely new thinking and possibility when planning a network design, it is important that all the possibilities are considered at the planning stage to fully utilize the cables potential. In this handbook, there is information about the steps required for planning, designing, choice of materials, construction instructions and maintenance issues.

The Universal cable concept provides the possibility to install in a way that has superior safety aspects compared to traditional methods. How this is dealt with in relation to specifications and safety regulations can be found on page 46. Details for use as a spare cable, especially EXCEL 3x10/10 12 kV, in both 12 and 24 kV networks can be found on page 49.

Universal cable concept – what is it?

The definition "Universal cable concept" is not only a description of a cable but a whole system of components and instructions. To gain full benefits, technically and economically, from the system it is important to take into consideration and use the factors that makes it a **system**.

A wide programme of accessories and instructions as well as aids for planning, designing are included in the system description. Regulating tables can be found in the chapter Design instructions in this handbook. Advice and rules for construction are in the chapter *Construction instructions* and maintenance issues are in the *Maintenance* chapter.

An important question in introducing a new system is network security and safety. The universal cable concept has through many installations proved its safety. Additional tough field tests have been carried out by EA Technology.

Cable design

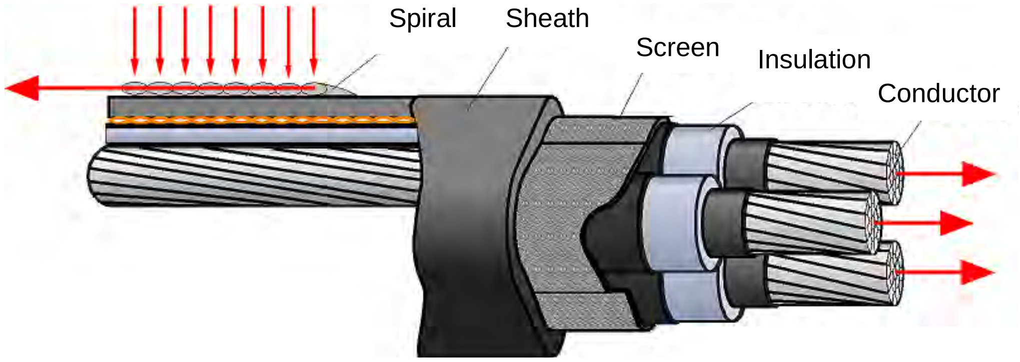
The cables called universal cables have some important common properties. They have to withstand all the different conditions of being installed underground, in water and in air. For laying underground the cable has to be robust and easy ploughable. For laying in water it is important that the density makes the cable sink. Maybe the greatest demands on the cable design are when it is used as self-supporting aerial cable.

To withstand the sometimes extreme conditions a cable in air can be exposed to with ice loading, storms and trees heavy from snow, a special cable design as the patented EXCEL and AXCES™ is required.

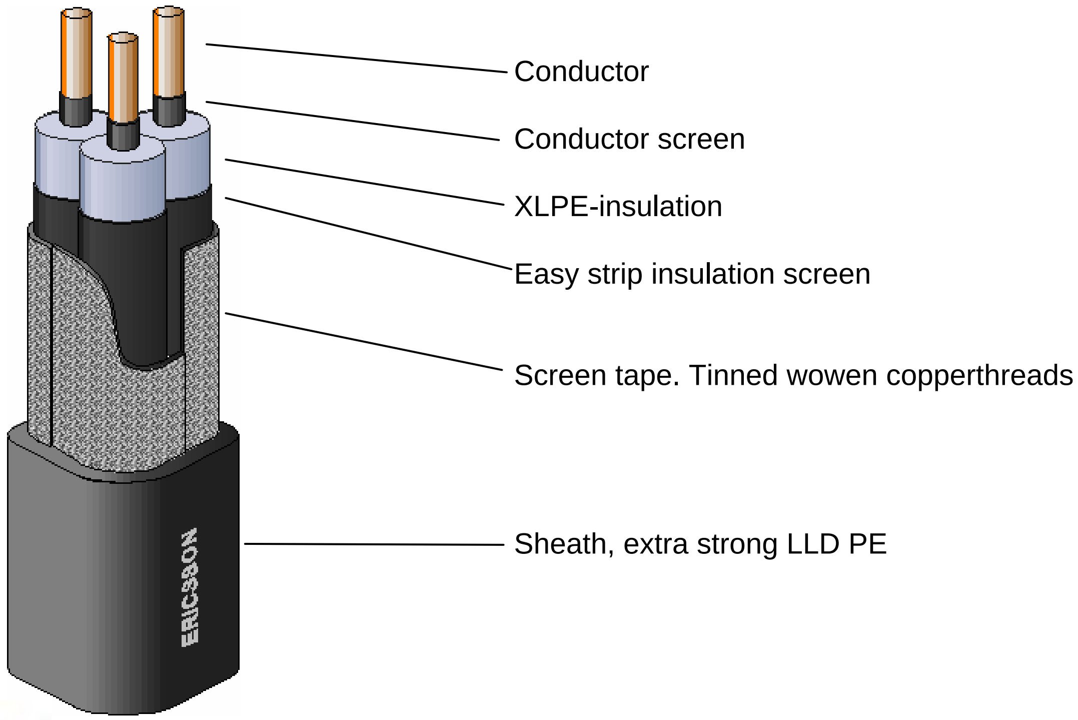
EXCEL 3x10/10 12 kV

AXCES™ 3x95/25 24 kV

In a self-supporting cable, type EXCEL/AXCES™, it is the conductors that take the greatest part of the pulling tension in the cable. As the conductors are live the tensioning cannot be made direct on the conductors, the axial forces have to be transmitted through the outer sheath and insulation system to the supporting conductor, without damaging the insulation system. How this functions is shown in the cross section of a universal cable below.

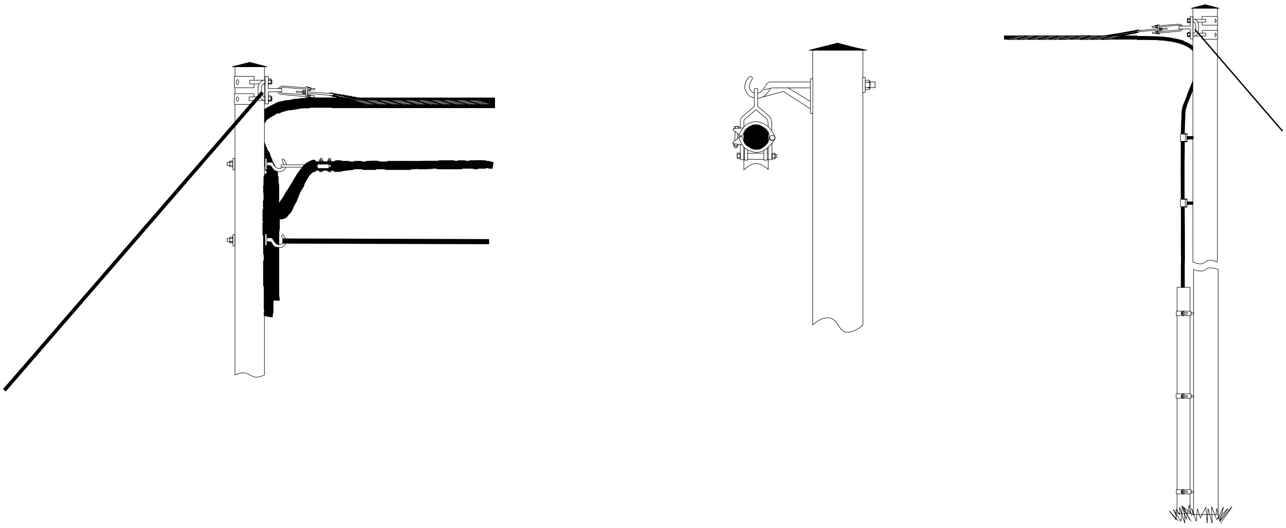


At both suspension clamps and dead end spirals the cable can be exposed to large forces for a long period of time, e.g. a tree heavy with snow lying on the line. Therefore the cable has to be designed so that the different layers do not slip against each other and that the screen threads are prevented from protruding into the outer semi-conducting layer. A conventional cable designed for underground use does not fulfil these demands. The universal cables EXCEL/AXCES™ are, through their unique design, adaptable for the different circumstances when used as self-supporting aerial cables.



Accessories

To make the universal cable concept a well functioning system it is necessary to have a range of accessories to construct the line and to have the aids required to design the line.



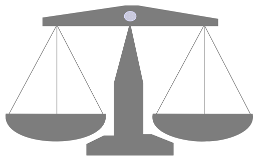
To maintain the properties of the installation it is important to use only approved accessories with the cable. Only then will the line fulfil its expectations.

We strongly recommend that only accessories described in this handbook, or in other ways approved by Ericsson, are used. In case of doubt, contact Ericsson for advice.

Planning instructions and advice

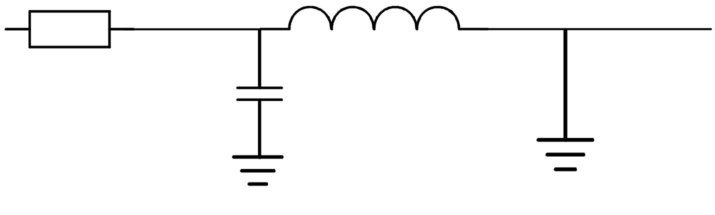
The first evaluation is to consider different solutions in line route topography. This often depends on the type of installation, i.e. rebuilding an old line, new installation or expansion of the existing network. By having the possibility of being able to utilise the same cable underground, overhead and in water or a combination of these different installation methods, provides greater freedom when choosing routes. The use of universal cable means that there is no need to have separate underground cables to the overhead line, just install the universal cable that is most suitable for each part of the route.

To select the best route is an important part in achieving the best economy from the network.



Factors to consider are:

- Possibilities to build together with existing or planned LV or telecom lines.
- Greater freedom in location of transformers.
- No need for lightning arrestors and separate cables for transformer connections.
- The sensitivity to lightning over-voltages are much reduced in comparison with bare conductors and covered conductors.
- Possibility to run alongside public roads. Therefore easier to inspect from the car.
- High degree of safety gives the possibility to go overhead where it is not possible to use bare or covered conductors.
- The reduced operation and maintenance costs of a cable network.
- Appearance, a cable is less visible, can go low (4.5 or 6 m in rural or suburban areas) or underground.



An electrical factor also to be considered is that a cable provides a capacitive load that is often advantageous in rural networks. Compared with a bare/covered conductor line the voltage drop is lower for a cable line. More about that in the next chapter.

Conclusion: A study of the total economy should be done, e.g. by an LCC- analyses or similar to determine the cost effectiveness.

Electrical matters – influence on network?

A cable network has other electrical properties that differ from a network built with bare or covered conductor overhead lines, whether the cable is laid underground or if it is hanging between poles. The cable built overhead between poles can be dealt with in the same way as an underground cable. The same methods of earthing and dealing with earth fault currents shall be used.

The electrical background to the differences is that a cable solution is capacitive while an overhead line is reactive.

When choosing a circuit breaker, consideration has to be made to the fact that a cable with low load has a capacitive current with a phase angle that can be up to 90°. To the circuit breaker a small capacitive current can be as difficult to break as a short circuit current.

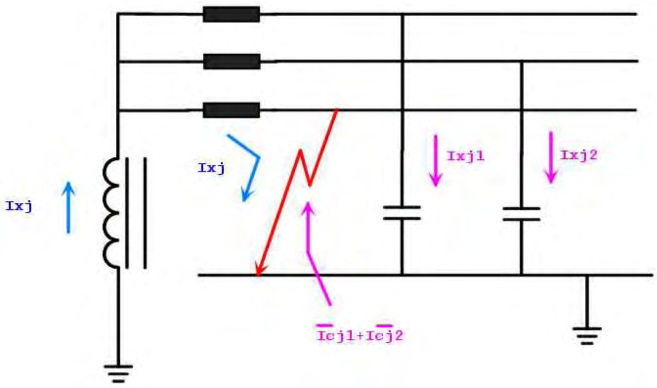
Connection or disconnection of one phase on long cable lines with, for example, high voltage fuses, shall be avoided, as this operation gives an unsymmetrical earth fault current. This unsymmetrical earth fault current can be detected by protection devices higher up in the network that in turn would cause disconnection of parts of the network.

Earth fault currents

The use of cable in the network means that the capacitive earth fault current increases in the range of 30-50 times compared with bare/covered conductors. This means that there is an increase demand on compensation and breaking capacity of the circuit breakers.

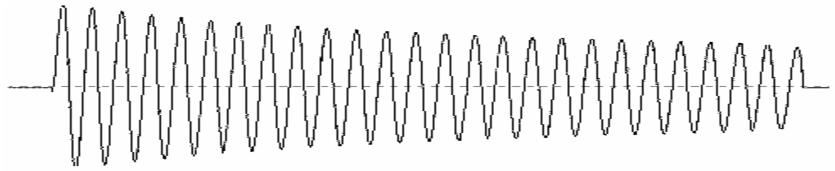
Earthing of installations is most often specified in safety regulations. On a non direct earthed high voltage network the earth fault current depends on the connection of the network to earth. The capacitive earth fault current in a cable network can be 0.7 – 2.8 A/km depending on the conductor size and voltage level.

The most common way to reduce the earth fault current is to connect a zero point reactor between the zero point of the system and earth. This will give a current in counter phase, which will compensate the earth fault current fully or partly.



Zero point reactor to compensate earth fault currents

Short circuit currents



Cable type EXCEL 3x10/10 12 and 24 kV with the conductor size 10 mm² has of course a limited short circuit strength; the data sheet states 2 kA for 1 sec. This often limits the use to radials in the network or as a satellite cable.

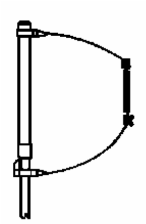
Due to the small conductor size, the resistance in the cable is relatively high and it increases at a high conductor temperature, e.g. at a short circuit. This fact will limit the short circuit current so that a short circuit has to happen close to the feeder point if the current reaches 2 kA. Calculations and short circuit tests done at NEFI high voltage laboratory in Skien, Norway shows that EXCEL 3x10/10, to a certain degree, is self protected if a short circuit happens longer than 500 m away on 10 kV and 1000 m on 20 kV

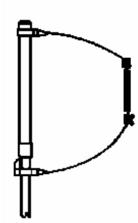
If EXCEL 3x10/10 is exposed to a short circuit current >2 kA for 1 sec (or equivalent current x time) it has proven by short circuit tests that the conductor burns off at the cable lug as the conductor has a slightly reduced area and has no cooling from the insulation material. This normally happens before the cable gets damaged and one can say that the cable to some extent is self-protecting.

How to protect the cable? The answer depends on a lot of factors, cable length, the probability for faults, what type of faults can be expected, what kind of protection is used on the overhead network, what kind of consequences can be accepted and so on.

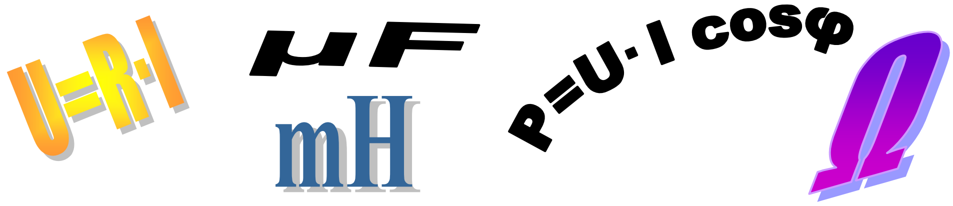
At a satellite cable, fuses are often used before the transformer and these then protect the cable also against overload and transformer faults. If the cable itself should be damaged by external violence this will lead to an earth fault normally detected by protection on the overhead network and disconnection will occur. A connection without fuses or breakers of a satellite cable to a ring network is acceptable as the probability for faults are very small and the damage that can occur is limited.

A high voltage fuse in the feeding end always protects the cable. A problem that then can happen is that, if the fuses are connected or disconnected one at a time then the capacitive earth fault current gives an unbalance which can be detected in the network and cause disconnection.





Voltage drop



Voltage-goodness is a definition, which with different criterion describes the quality on the supply of electricity in a network. As well as the high voltage side, the low voltage side has an influence on the voltage goodness and when a bare covered conductor line is changed to cable the voltage goodness normally improves. Net impedance reduces, short circuit power in the network increases and the voltage variations reduce.

A line with cable is, as mentioned earlier, a capacitive load whilst a bare/covered conductor line is an inductive load. This means that the voltage drop becomes lower for a line with EXCEL/AXCES™ than with a line of bare/covered conductor as the inductive voltage drop in the cable is almost zero. A conventional overhead line has about 0.4 ohms/km and AXCES™ 3x95 has 0.09 ohms /km reactance, see the table below. The values are valid for a load of 100A and an air temperature of 20°C

	Resistance Ω/km	**Total impedance** Ω/km	**Voltage drop/km** 12 kV phase-phase at 100 A load	**Voltage drop/km** 24 kV phase-phase at 100 A load
AXCES™ 3x95	0.32	0.33	0.48 %	0.24 %
BLX 99 mm^2	0.31	0.48	0.70 %	0.35 %
BLX 241 mm^2	0.13	0.36	0.52 %	0.26 %

The table shows that with AXCES™, under normal loading conditions, it is possible to increase the network length between substations by up to 40-50 % against a standard bare/covered conductored overhead line. This gives the possibility to strengthen networks with volt drop problems by changing to AXCES™. The voltage drop of a 95 mm^2 AXCES™ can be compared with a BLX 241 mm^2

A phenomenon that can occur with long cable lines and low load is a voltage rise. The factors that influence the voltage rise are apart from cable length, low load, low short circuit effect and small transformer effect at cable ends. Overtones in the network can increase the effect. The simplest way to solve the problem is to use bigger transformers at the cable ends to compensate for the voltage rise and at the same time will provide a very stable network. A transformer size of 500 kVA or more at the feeding end will perform very well. This phenomenon has a practical influence on long lines of more than 5 – 10 km only, with loads of a few kVA when the voltage rise can be a few percent.

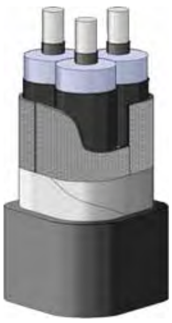
Lightning over-voltages

In areas where it normally is a problem with induced over-voltages the cable alternative offers a lot of advantages compared to bare/covered conductors. Some of the main points can be identified as follows:

- From an electrical point of view there is no difference between cable in ground or in air
- By experience a cable is much less exposed to problems with lightning over-voltages than lines with bare/covered conductors.
- The risk for a direct strike is reduced when using EXCEL/AXCES™ universal cable instead of bare/covered conductors.
- The risk for interruptions due to induced over-voltages are very much reduced by the use of EXCEL/AXCES™

In principal three different designs with different properties can be studied:

Cable (EXCEL/AXCES™)



<u>Design</u>

Conductor

Conductor screen
Insulation
Insulation screen

Metallic screen

Insulating jacket

No external electrical field

AXUS

<u>Design</u>

Conductor

Conductor screen

Insulation

Insulation screen

Small external electrical field

Bare or covered conductor

<u>Design</u>

Conductor

Covering

Large external electrical field

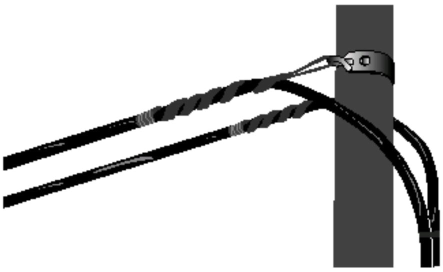
Direct strikes

The probability for a direct strike on an EXCEL/AXCES™ type universal cable installed in an overhead line is less than for bare/covered conductors and is in principle not greater than a cable installed underground.

The reason for this is that EXCEL/AXCES™ are screened products and therefore have an earth potential surrounding the cable. The air around the cable will not ionise as it does on a bare/covered conductor, the lightning does not "see" the cable in the same way as a bare/covered conductor. The outer sheath of PE also insulates the earthed screen, which also reduces the risk of a direct strike. A cable installed in an overhead line in an exposed area is of course more likely to be struck than a cable buried underground.

A direct strike on the cable will probably cause a fault that has to be repaired no matter if the cable is installed underground or overhead. One way to reduce the risk of a direct strike on an overhead line is to install an earth wire above the cable. This can also give extra protection if a tree falls on the line, especially on EXCEL with its slightly lower mechanical strength.

Service experiences over the years for Universal cable installations are very good. In areas subjected to severe thunderstorms several pole-mounted transformers were destroyed in the bare wire part of the net while the part equipped with Universal cables had no failures.



Induced over voltages

Induced voltages are present in all electrical conductors that are exposed to irregular electromagnetic fields, e.g. lightning. The problems with induced over-voltages, are present in all types of electrical conductors, bare/covered conductors, cable on poles and even cable underground.

This phenomenon however gives different consequences depending on the design of the network.

In a bare conductor the induced over-voltage in the conductor will give a flash over, usually between phase and the crossarm. The flash over will light a 50Hz arc with a current depending on the network. The arc then continues along the conductor in the direction of the load and normally no damage occurs before disconnection happens. After reconnection the power distribution continues. The disadvantage is the disconnection of the supply

In a covered conductor the induced over-voltage in the conductor will lead to a flash over in the same way as for a bare conductor. Also here a 50Hz current arc will form. As the arc cannot continue along the conductor, depending on the insulation, the conductor can be burnt off unless protection is in the form of arcing horns is fitted. In the event of this protection measure being in place the same situation as for a bare conductor will happen, that is an interruption of the supply before reconnection.

In a cable that is a screened product the over-voltage is induced in the screen. The screen is connected to earth at both ends and normally the over-voltage is lead to earth at the earthing points. At long cable lengths (several km) the earthing points can be so far away from each other that theoretically the overvoltage can go through the cable sheath to find its path to earth, e.g. where the cable is taken into ground. This will, however, not result in an arc as it only the induced over-voltage that is lead away. It is a relatively low energy source and can possibly result in a minor puncture of the sheath. This will not damage the overall performance of the cable and will not disturb the power supply at all.

This phenomenon affects cable in air as much as in traditional buried cables and is not a problem in practice.

Design instructions

General instructions

At the planning stage when routing new lines, it is important to evaluate the new possibilities that the universal cable provides. By utilising the different possibilities of using the cable, in air, ground or water it is possible to achieve further cost reductions in investment costs as well as having the advantages in operation and maintenance. The locality of substations can be made with more freedom, the possibility to follow roads, go underground and if possible build lines together with LV and telecom.

With reference to EXCEL, EBR (Swedish Electricity Users) has published a design standard K28:96 (available in English) that provides guidance when designing, the general advice is also applicable to AXCES™.

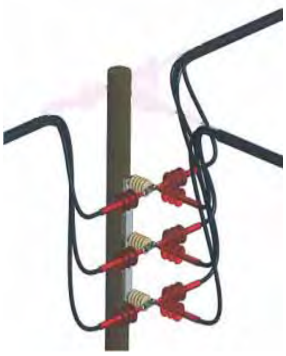
At the design stage there are some points that should be considered to make the installation as smooth as possible. It is, among other things, rational to think where any eventual joints will be located and what cable lengths require to be ordered.

Down-droppers/Joints

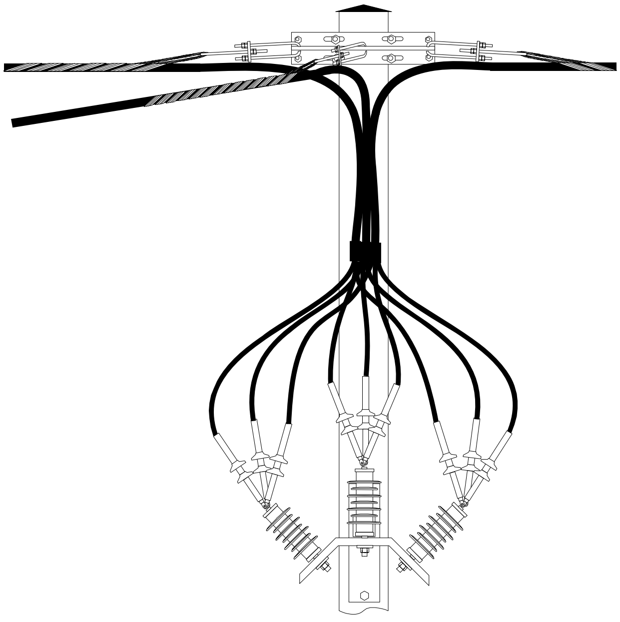
There are different methods for making down-droppers or joints, the most common are:

- Direct, screened, joint underground or down-dropper on the pole.
- Down-dropper with terminations on support insulator or lightning arrestor.
- Down-dropper with disconnecting possibilities in a ground mounted cabinet.
- Parallel from terminal/section pole then tee-off.

All the above methods fulfil the same intention. The chose depends on the requirement for possible disconnection points, appearance, and location. It is important to realise that a cable is not exposed to faults the same as bare/covered conductors. This will often decrease the requirement for disconnection. A direct-screened down-dropper/joint also has the advantage that it is fully insulated.



Down-dropper with termination on insulator or lightning arrestor.



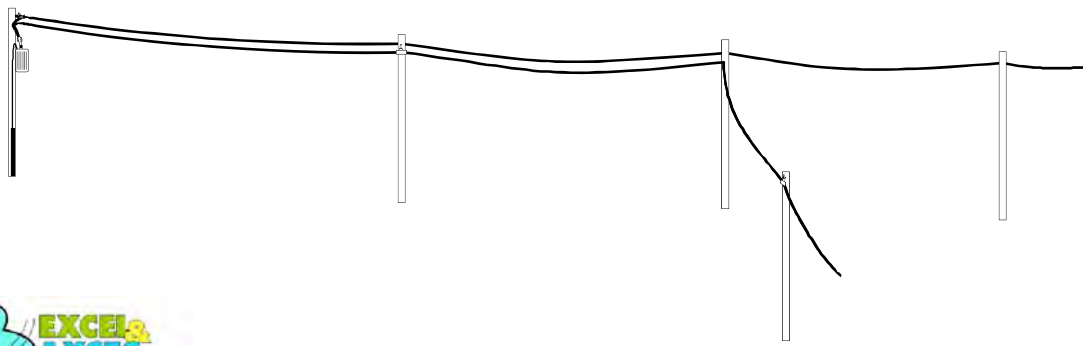
With an end termination on an insulator or lightning arrestor it allows for easier disconnection. The insulators can be mounted on the support for lightning arrestors and are preferable below the cable. There is no need for lightning arrrestors unless there is a bare wire ore BLX connected at the junction point. It is easier to make a proper mounting if the distance between the fitting points for the cables and the connection points are large enough. There is a protection cap available to protect the connections from birds.

Down-dropper with disconnection possibilities on the ground.

The cables run down the pole into the ground and are terminated in a disconnector cabinet. Today there are flexible disconnecting cabinets available that are suitable for earthed cables. They provide simple and quick possibilities for disconnection. With this solution there are no exposed live parts. The disconnection cabinet need not necessarily be placed at the foot of the pole; it can be located at the most suitable place as the cables can go underground from the pole to the cabinet.

Parallel from terminal pole and make a down-dropper.

If the down-dropper is to be made close to an existing terminal/section pole (a few spans) it can in many cases be simpler and cheaper to go back parallel to the nearest existing down-dropper and branch off from there. In this way possible sources for faults are reduced as fewer terminations and parts that not are semi protected are used. The spur line can also be disconnected from the terminal/section pole.

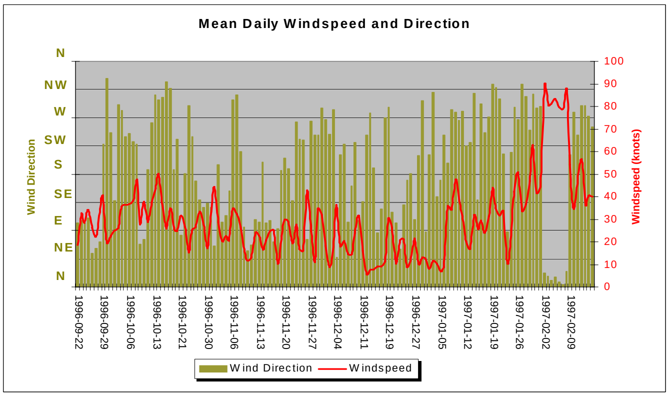


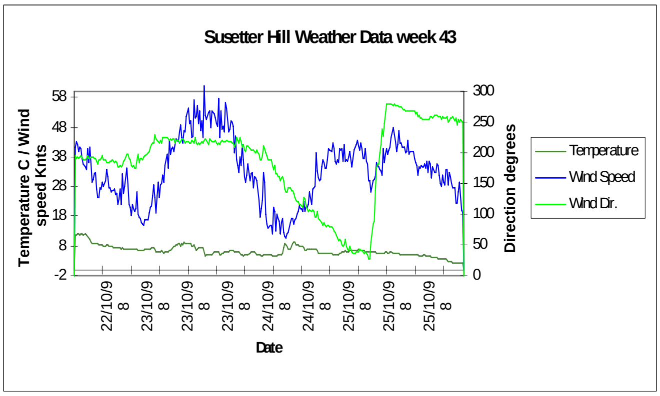
Wind loads

A bare line or a cable subjected to wind will be affected in different ways. Factors to take into consideration are of course the wind speed and direction. She shapes of the line or cable is also important. The internal design of the cable affects the way vibrations and galloping are damped by the cable.

Ericsson Network Technologies has done calculations as well as field tests in order to determine the forces on the cable under wind load conditions.

At EA Technology's test field on the Shetlands the Universal cables EXCEL and AXCES™ were strung up on poles on spans up to 90 meters for a period of 18 months [1]. The cables were monitored by load cells and video cameras and performed extremely well. The figures below shows some of the data on the weather conditions with wind speeds (10 minutes average) of up to 82 knots (94 mph).





The increase in tension in the cables was moderate as can be seen in the table below, showing the figures for a 90-meter span.

Wind speed knots / m/s	Increase of tension in cable kN	
	EXCEL	AXCES™
19 / 10	0.22	0.29
39 / 20	0.49	0.67
58 / 30	0.78	1.09
78 / 40	1.25	1.49

Wind force on cable kN *Wind forces calculated with form factor μ=0.5*	
EXCEL	AXCES™
0.1	0.2
0.4	0.6
0.8	1.3
1.4	2.2

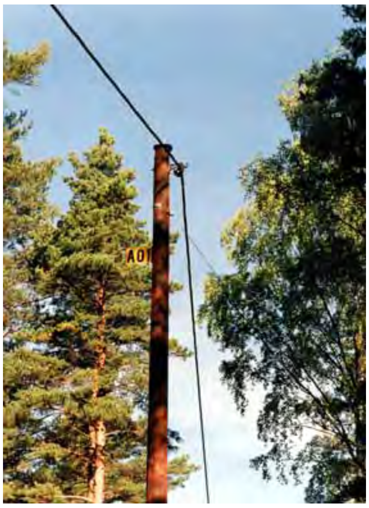
The cables were monitored by video cameras during the test and there was no indication of galloping or vibration throughout the test period, nor any significant problem with snow or ice loading.

Possible explanations for this is that the triangular shape of the cable "breaks" the wind flow and the internal design helps damping out the vibrations.

Swathes, routes

As EXCEL/AXCES™ are fully insulated screened cables there is no requirement for broad swathes to eliminate the risk of trees bending over the line. Branches should be avoided from lying against the cable for long times as abrasion damage can occur. It is an advantage to keep the swathes narrow for several purposes.

- The cost for buying out forest from the owner is considerably less.
- Trees standing closer protect each other and there is a reduced risk of trees falling over the line in severe conditions.

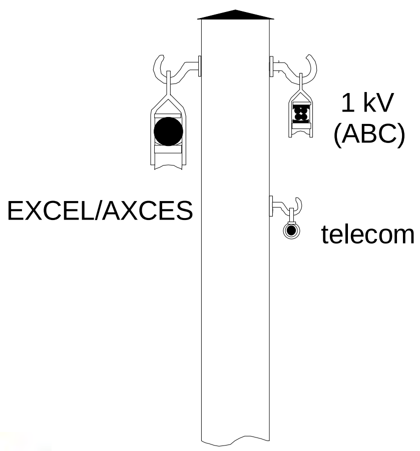


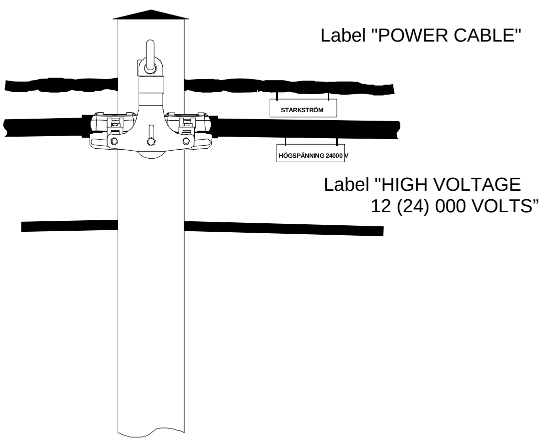
To follow existing roads can often be a good solution.

When replacing/refurbishing an existing network with bare conductors it is important to think of all the possibilities with the cable solution, (overhead, underground, water, routing). To achieve the best security of supply it is often best to build with "hard connections" and few down-droppers and joints.

Building MV, LV and telecom on same poles

There are great opportunities to use the same poles for medium voltage, low voltage, street lightning and telecom. In Sweden for instance it is allowable to build as follows:





Building together is very often efficient and cost effective.

Crossing road or railway.

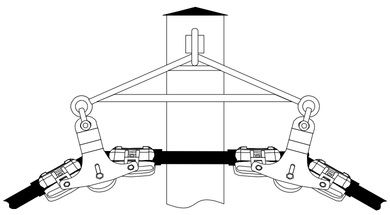
Crossing a public road or railway has to be made according to Electricity regulations / specifications and road or rail authority specifications. As the cable is self supporting there is no need for a special carrier. The fact that the cable is fully insulated and screened has to be considered. Span lengths may be reduced and the cable can be fixed with dead end spirals at the poles either side of the crossing. A cable joint in the crossing is not allowed. The height over the road or rail has to be considered.

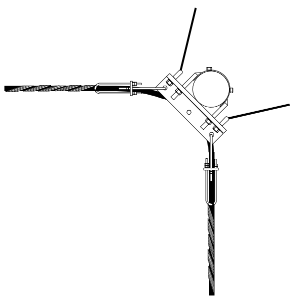
Angles, extra suspension

At situations where the angle is greater than what the suspension clamps can handle a double lock with two suspension clamps can be used to double the allowable angle. With even greater angles then these have to be relieved with two dead end spirals in both directions.

The use of dead end spirals can be utilised at other cases such as:

- At a line with big differences in height it may be necessary to relief hang close to the highest point to avoid all of the cable weight being taken up by the suspension clamp.
- If there are two spans close to each other with a big difference in span lengths it can be necessary to relieve with spirals to get equal sag.
- If there is a long section of line it can be practical both from construction and maintenance point of view to relieve the line at suitable places.





Designing EXCEL and FXCEL

EXCEL 3x10/10 is designed for a normal span of 70 metres, maximum 90 metres. FXCEL 3x16/10 is designed for a normal span of 80-90 metres, maximum 110 metres. The cables are tensioned according to the regulation tables below. The easiest way of designing overhead lines is by using a design program, data for which is given below. Some of the commercial design programs already have the data for EXCEL/FXCEL included from the supplier.

The tables below is calculated so that the sag at 0°C with the cables own weight at 70 m span will be about 2.5% of the span length.

REGULATIONS TABLE, INSTALLATION OF EXCEL 3x10/10 12 kV

Temperature at time of installation °C	Tension kN	Sag in metres with a **span** length of				
		50	**60**	**70**	**80**	**90**
20	2.5	1.0	1.4	1.9	2.5	3.1
10	2.6	1.0	1.4	1.8	2.4	3.0
0	2.7	0.9	1.3	1.7	2.3	2.9
-10	2.8	0.9	1.3	1.7	2.2	2.8
-20	2.9	0.8	1.2	1.6	2.1	2.7

REGULATIONS TABLE, INSTALLATION OF EXCEL 3x10/10 24 kV

Temperature at time of installation °C	Tension kN	Sag in metres with a **span** length of				
		50	**60**	**70**	**80**	**90**
20	3.0	1.0	1.4	2.0	2.6	3.3
10	3.1	1.0	1.4	1.9	2.5	3.2
0	3.2	0.9	1.3	1.8	2.4	3.1
-10	3.3	0.9	1.3	1.7	2.3	3.0
-20	3.4	0.8	1.2	1.7	2.2	2.9

REGULATIONS TABLE, INSTALLATION OF FXCEL 3x16/10 12 kV

Temperature at time of installation °C	Tension kN	Sag in metres with a **span** length of						
		50	**60**	**70**	**80**	**90**	**100**	**110**
20	3.8	0.85	1.22	1.66	2.2	2.7	3.4	4.1
10	3.95	0.81	1.17	1.59	2.1	2.6	3.2	3.9
0	4.1	0.78	1.12	1.53	2.0	2.5	3.1	3.8
-10	4.3	0.75	1.08	1.46	1.9	2.4	3.0	3.6
-20	4.5	0.71	1.03	1.40	1.8	2.3	2.85	3.45

REGULATIONS TABLE, INSTALLATION OF FXCEL 3x16/10 24 kV

Temperature at time of installation °C	Tension kN	Sag in metres with a **span** length of						
		50	**60**	**70**	**80**	**90**	**100**	**110**
20	4.2	1.05	1.51	2.06	2.7	3.4	4.2	5.1
10	4.3	1.02	1.47	2.00	2.6	3.3	4.1	5.0
0	4.4	0.99	1.43	1.95	2.5	3.2	4.0	4.8
-10	4.5	0.97	1.39	1.89	2.5	3.1	3.9	4.7
-20	4.7	0.94	1.35	1.84	2.4	3.0	3.8	4.5

DESIGN TABLE, EXCEL 3x10/10 12 kV (def. strain 67.5 N/mm^2 at 0ºC)

Normal span m	Sag in metres, and force with ice load at a span length of, metres				
	50	**60**	**70**	**80**	**90**
Conductor temp. +50 °C	1.6	2.1	2.6	3.2	3.9
Conductor temp. +65 °C	1,7	2,2	2,7	3,3	4,0
Short circuit	2.3	2.9	3.5	4.2	4.9
Force at 0 °C and 2 kg/m ice load	6.5 kN	7.0 kN	7.5 kN	7.8 kN	8.1 kN

DESIGN TABLE, EXCEL 3x10/10 24 kV (def. strain 80 N/mm^2 at 0ºC)

Normal span m	Sag in metres, and force with ice load at a span length of, metres				
	50	**60**	**70**	**80**	**90**
Conductor temp. +50 °C	1.7	2.3	2.9	3.6	4.5
Conductor temp. +65 °C	1,8	2,4	3,0	3,7	4,6
Short circuit	2.4	3.0	3.7	4.5	5.4
Force at 0 °C and 2 kg/m ice load	6.6 kN	7.0 kN	7.4 kN	7.7 kN	7.9 kN

DESIGN TABLE, FXCEL 3x16/10 12 kV (def. strain 75 N/mm^2 at 0ºC)

Normal span m	Sag in metres, and force with ice load at a span length of, metres						
	50	**60**	**70**	**80**	**90**	**100**	**110**
Conductor temp. +50 °C	1.3	2.1	2.3	2.8	3.4	3.9	4.7
Conductor temp. +65 °C	1.4	2.2	2.4	2.9	3.5	4.0	4.8
Short circuit	2.0	2.7	3.1	3.7	4.3	5.0	5.7
Force at 0 °C and 2 kg/m ice load	7.8 kN	8.4 kN	9.0 kN	9.5 kN	9.9 kN	10.3 kN	10.6 kN

DESIGN TABLE, FXCEL 3x16/10 24 kV (def. strain 80 N/mm^2 at 0ºC)

Normal span m	Sag in metres, and force with ice load at a span length of, metres						
	50	**60**	**70**	**80**	**90**	**100**	**110**
Conductor temp. +50 °C	1.4	1.9	2.5	3.1	3.8	4.5	5.4
Conductor temp. +65 °C	1.3	1.8	2.4	3.0	3.7	4.4	5.3
Short circuit	2.0	2.6	3.2	3.9	4.6	5.5	6.3
Force at 0 °C and 2 kg/m ice load	7.8 kN	8.4 kN	8.9 kN	9.3 kN	9.6 kN	9.9 kN	10.1 kN

Very low temperatures (-40 C°) can give high forces. When using short normal spans the force should be decreased when adjusting the line.

Line Design with EXCEL/FXCEL

The design of overhead lines is easiest done with the aid of a computerised design program. The following cable data are applicable for most computer programs:

	EXCEL 3x10/10 12 kV	**EXCEL 3x10/10 24 kV**	**FXCEL 3x16/10 12 kV**	**FXCEL 3x16/10 24 kV**
Area	40 mm^2	40 mm^2	55 mm^2	55 mm^2
Diameter	29 mm	38 mm	31 mm	40 mm
Q_e = Cable weight	0.85 kg/m	1.22 N/m	1.03 kg/m	1.4 kg/m
E_{ik} = Elasticity modulus before ice load	96 000 N/mm^2	75 000 N/mm^2	80 000 N/mm^2	78 000 N/mm^2
E_p = Elasticity modulus after permanent creeping. (after ice load)	111 000 N/mm^2	87 000 N/mm^2	100 000 N/mm^2	98 000 N/mm^2
τ_p = permanent elongation or permanent creeping	0,5 %	0,5 %	0,4 %	0,5 %
Coefficient of linear expansion	$20 \cdot 10^{-6}$ /^{o}C	$20 \cdot 10^{-6}$ /^{o}C	$18 \cdot 10^{-6}$ /^{o}C	$18 \cdot 10^{-6}$ /^{o}C
Definitude strain 0^o C	67,5 N/mm^2	80 N/mm^2	75 N/mm^2	80 N/mm^2
Maximum continous load on cable in calculations	8.1 kN	8.5 kN	11 kN	11 kN
Approximate fast break load for cable	20 kN	22 kN	25 kN	25 kN
Approximate long term breaking load	>=15 kN	>=15 kN	>=17 kN	>=17 kN

Designing AXCES™

AXCES™ 3x70/16 and 3x70/25, 3x95/25 are designed for a normal span of 100 to 110 metres, normal span up to 120 to 140 metres under favourable conditions. Maximum spans can be considearbly longer. The cables are tensioned according to the regulation tables below. The easiest way of designing overhead lines is by using a design program, data for which is given below. Some of the commercial design programs already have the data for AXCES™ included from the supplier.

The tables below are calculated so that the sag at 0ºC with the cables own weight at 100m span will be at about 2.5% of the span length.

REGULATIONS TABLE, INSTALLATION OF AXCES™ 3x70/16 12 kV

Temperature at time of installation °C	Tension kN	Sag in metres with a span length of (def. strain 42 N/mm^2 at 0ºC)						
		60	80	90	100	110	120	140
20	8.3	0.87	1.55	1.96	2.4	2.9	3.5	4.7
10	8.7	0.83	1.47	1.86	2.3	2.8	3.3	4.5
0	9.2	0.78	1.39	1.75	2.15	2.6	3.1	4.2
-10	9.8	0.73	1.30	1.65	2.0	2.4	2.9	4.0
-20	10.5	0.68	1.21	1.54	1.9	2.3	2.7	3.7

REGULATIONS TABLE, INSTALLATION OF AXCES™ 3x70/16 24 kV

Temperature at time of installation °C	Tension kN	Sag in metres with a span length of (def. strain 46 N/mm^2 at 0ºC)						
		60	80	90	100	110	120	140
20	9.1	0.87	1.55	1.96	2.4	2.9	3.5	4.7
10	9.6	0.83	1.47	1.86	2.3	2.8	3.3	4.5
0	10.1	0.78	1.39	1.75	2.15	2.6	3.1	4.2
-10	10.8	0.73	1.30	1.65	2.0	2.4	2.9	4.0
-20	11.5	0.68	1.21	1.54	1.9	2.3	2.7	3.7

REGULATIONS TABLE, INSTALLATION OF AXCES™ 3x95/25 12 - 24 kV

Temperature at time of installation °C	Tension kN	Sag in metres with a span length of (def. strain 35 N/mm^2 at 0ºC)					
		60	80	90	100	110	120
20	9.6	1.1	1.9	2.2	2.8	3.4	4.0
10	10.0	1.0	1.8	2.2	2.7	3.2	3.8
0	10.5	0.9	1.6	2.1	2.5	3.1	3.7
-10	11.0	0.8	1.5	1.9	2.4	2.9	3.5
-20	11.6	0.7	1.4	1.8	2.2	2.8	3.4

REGULATIONS TABLE, INSTALLATION OF AXCES™ 3x70/25 36 kV

Temperature at time of installation °C	Tension kN	Sag in metres with a span length of (def. strain 46 N/mm^2 at 0ºC)					
		60	80	90	100	110	120
20	9.4	1.0	1.8	2.1	2.6	3.2	3.8
10	9.9	0.9	1.7	2.1	2.5	3.0	3.6
0	10.3	0.8	1.6	2.0	2.4	2.9	3.5
-10	11.0	0.8	1.4	1.8	2.3	2.8	3.4
-20	11.6	0.7	1.3	1.7	2.1	2.7	3.3

Line Design with AXCES™

DESIGN TABLE, AXCES™ 3x70/16 12 kV (def. strain 42 N/mm2 at 0ºC)

	Sag in metres, and force with ice load at a span length of, metres						
Normalspann m	60	80	90	100	110	120	140
+50 C°.	1.7	2.5	2.9	3.4	3.9	4.5	5.8
+65 C°	1.8	2.6	3.0	3.5	4.1	4.6	5.9
Short circuit	2.7	3.8	4.3	4.9	5.5	6.2	7.5
Force at 0 °C and 2 kg/m ice load	kN 12.4 *	kN 14.2	kN 14.9	kN 15.6	kN 16.2	kN 16.7	kN 17.5

** Very low temperatures (-40 C°) will give very high forces. When using short normal spans the force should be decreased when adjusting the line.*

DESIGN TABLE, AXCES™ 3x70/16 24 kV (def. strain 46 N/mm2 at 0ºC)

	Sag in metres, and force with ice load at a span length of, metres						
Normalspann m	60	80	90	100	110	120	140
+50 C°.	1.7	2.5	2.9	3.4	3.9	4.5	5.8
+65 C°.	1.8	2.6	3.0	3.5	4.1	4.6	5.9
Short circuit	2.7	3.7	4.3	4.9	5.5	6.2	7.6
Force at 0 °C and 2 kg/m ice load	kN 12.9 *	kN 14.8	kN 15.6	kN 16.2	kN 16.8	kN 17.4	kN 18.2

** Very low temperatures (-40 C°) will give very high forces. When using short normal spans the force should be decreased when adjusting the line.*

DESIGN TABLE, AXCES™ 3x70/25 36 kV (def. strain 46 N/mm2 at 0ºC))

	Sag in metres, and force with ice load at a span length of, metres						
Normalspann m	60	80	90	100	110	120	140
+50 C°.	1.9	2.8	3.3	3.9	4.5	5.2	6.6
+65 C°.	2.0	2.9	3.5	4.1	4.7	5.4	6.9
Short circuit.	2.9	4.0	4.6	5.3	6.0	6.7	8.4
Force at 0 °C and 2 kg/m ice load	kN 13.1 *	kN 14.8	kN 15.5	kN 16.1	kN 16.6	kN 17.0	kN 17.7

** Very low temperatures (-40 C°) will give very high forces. When using short normal spans the force should be decreased when adjusting the line.*

DESIGN TABLE, AXCES™ 3x95/25 12 + 24 kV (def. strain 35 N/mm2 at 0ºC)

	Sag in metres, and force with ice load at a span length of, metres						
Normalspann m	60	80	90	100	110	120	140
+50 C°.	1.9	2.8	3.3	3.9	4.5	5.2	6.6
+65 C°.	2.0	2.9	3.5	4.1	4.7	5.4	6.9
Short circuit	2.9	4.0	4.6	5.3	6.0	6.7	8.4
Force at 0 °C and 2 kg/m ice load	kN 13.1 *	kN 14.8	kN 15.5	kN 16.1	kN 16.6	kN 17.0	kN 17.7

** Very low temperatures (-40 C°) will give very high forces. When using short normal spans the force should be decreased when adjusting the line.*

Line Design with AXCES™

The design of overhead lines is easiest with a design program.
The following cable data are applicable:

	AXCES™ 3x70/16 12 kV	AXCES™ 3x70/16 24 kV	AXCES™ 3x70/25 36 kV	AXCES™ 3x95/25 12 - 24 kV
Area	210 mm^2	210 mm^2	210 mm^2	285 mm^2
Diameter	41 mm	45 mm	52 mm	49 mm
Q_e = Cable weight	16 N/m	17,5 N/m	20 N/m	22 N/m
E_{ik} = Elasticity modulus before ice load	55 000 N/mm^2	55 000 N/mm^2	55 000 N/mm^2	47 000 N/mm^2
E_p = Elasticity modulus after permanent creeping. (After ice load)	64 000 N/mm^2	64 000 N/mm^2	64 000 N/mm^2	61 000 N/mm^2
τ_p = Permanent elongation or permanent creeping	0.7 % 0.7 mm/m	0.7 % 0.7 mm/m	0.8 % 0.8 mm/m	0.8 % 0.8 mm/m
Coefficient of linear expansion	$23 \cdot 10^{-6} /^oC$	$23 \cdot 10^{-6} /^oC$	$23 \cdot 10^{-6} /^oC$	$23 \cdot 10^{-6} /^oC$
Definitude strain 0 °C	42 N/mm^2	46 N/mm^2	46 N/mm^2	35 N/mm^2
Maximum continous force on cable in calculations	27 kN	27 kN	27 kN	28 kN
Approximate fast break load for cable	55 kN	56 kN	57 kN	70 kN
Approximate long term break load	49 kN	49 kN	49 kN	51 kN

When designing it is necessary to change the cross-sectional area in the calculations. For AXCES™ 3x70/16 use 220 mm^2 (instead of 210 mm^2), and for AXCES™ 3x95/25 use 300 mm^2 (instead of 285 mm^2). This will give a better correspondence in the calculating programs.

When building with short spans it is recommended to decrease the “definitude strain” with say 20-30% in order to limit the forces on poles and stays. The sag is normally not a problem for short spans.

Accessories

General instructions

The use of the correct materials that are manufactured for the cable is essential to ensure a trouble-free and quality installation. With a universal cable erected in an overhead line the stresses that the cable can be exposed to, say if a tree falls over the cable, can be large therefore it is very important that only approved accessories are used. Especially important are the dead end spirals and the suspension clamps.

Terminations and joints from manufacturers other than the ones mentioned below can be used on condition that they are designed for the actual cable.

With EXCEL it is important that the termination or joint is designed to the small conductor size 10 mm², and contains suitable lugs and conductor sleeves

With AXCES™ it is important that lugs and conductor sleeves are suitable for a conductor with Al-alloy (Al59). Joints in a span with AXCES™ can be made as tension proof or tension relieved. If a joint is to be made in a span as tension proofed the conductor sleeve must be tension proof. The most uncritical design is as tension relieved

The materials listed below fulfil the requirements and can be used as guidance when choosing material considering other factrs as price and availability.

In doubtful cases, contact Ericsson for information.

Except for the materials listed below there may be a requirement for special tools to install the cable, information can be found in the chapter “Construction instructions”.

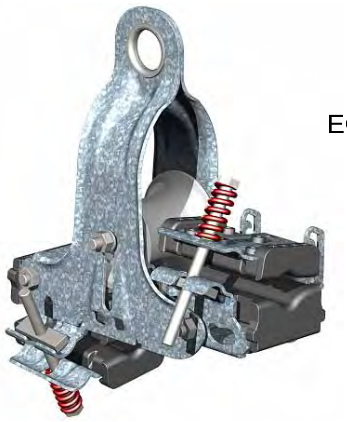
Suspension clamps

The suspension clamp has many tasks. The roller must enable quick and easy pullout of long lengths. Both ECH12 and ECH14 fulfil these demands. The suspension clamps SO99 and SO86 are primarily developed for ABC-type of low voltage cables and have limited capability with respect to pullout lengths and speed.

Under service conditions the clamps shall give a low surface pressure on the cables and also facilitate deviation angles.

<u>Which clamp to use for the cable?</u>

Cable	Clamp	NSH-No.	Maximum angle of deviation	Comments
EXCEL/FXCEL 12 kV	ECH12	NSH 401 194	45°	Best choice. Can be opened.
	SO99	NSH 401 107	30°	”ABC-clamp” with limited pull-out length. Can not be opened.
	SO86 + inset	NSH 401 105 NSH 401 104	35°	”ABC-clamp” with limited pull-out length. ”Open” clamp, the cable can be lifted into the clamp from the side.
EXCEL/FXCEL 24 kV	ECH12	NSH 401 194	45°	Best choice. Can be opened.
	ECH14	NSH 401 131	45°	
	SO86 + inset	NSH 401 105 NSH 401 104	35°	”ABC-clamp” with limited pull-out length. ”Open” clamp, the cable can be lifted into the clamp from the side.
AXCES 3x70 12 kV	ECH12	NSH 401 194	45°	Good choice. Can be opened.
	ECH14	NSH 401 131	45°	For heavy duty installations. With metal roller for extra long and heavy pull-outs. Can be opened.
AXCES 3x70 24 kV	ECH14	NSH 401 130	45°	
AXCES 3x70 36 kV	ECH14	NSH 401 130	45°	
AXCES 3x95 24 kV	ECH14	NSH 401 130	45°	



ECH12

ECH14

SO99

SO86

EXCEL & AXCES universal
Ericsson Network Technologies

Dead end spiral

The dead end spiral is used to transfer the axial force from the hook to the cable without damaging the insulation system within the cable. This must also be the case under extreme conditions like ice load, falling trees etc.

It is very important to use the correct dead end spiral according to the table below. The spirals are often colour coded and sometimes also ink jet printed on the wires.


Which dead end spiral to use for the cable?

Cable	Spiral	NSH-No.	Comment
EXCEL 12 kV	PLP 120-GRD-28/C/I GSDE3100L	NSH 401 128 -	Brand PLP. Colour mark Green Brand Dulmison
FXCEL 12 kV	PLP 125-GRD-31/C/I	NSH 401 188	Brand PLP. Colour mark Black
EXCEL/FXCEL 24 kV	PLP 130-GRD-38/C/I	NSH 401 129	Brand PLP. Colour mark Red
	GSDE4100L	-	Brand Dulmison
AXCES 3x70 12 kV	PLP 180-GRD-41/C/I	NSH 401 173	Brand PLP. Colour mark Orange
AXCES 3x70 24 kV	PLP 200-GRD-44/48/C/I	NSH 401 127	Brand PLP. Colour mark Blue
AXCES 3x70 36 kV	PLP 200-GRD-44/48/C/I	NSH 401 127	Brand PLP. Colour mark Blue
AXCES 3x95 24 kV	PLP 200-GRD-44/48/C/I	NSH 401 127	Brand PLP. Colour mark Blue


Tip: Mounting of the dead end spiral is much easier if one splits the spiral for the last turn or two, then 2-3 wires at a time is wound

Examples of accessories

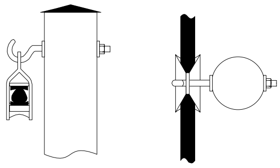
Below can be found examples of different material that can be used for building Universal cable lines. Hardware like hooks and bolts can be substituted with locally avalible material fit for the purpose. Suspension clamps and dead end spirals must however be of approved design.

Accessories for EXCEL 3x10/10 and FXCEL 3x16/10

(Example of kits used by the suppliers and utilities in Sweden)

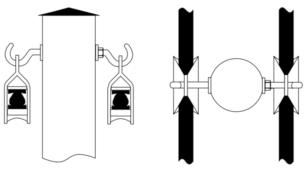
Straight line

		Ericsson No.	
1 off	EBR-kit 0170 (Hook, bolt, washer)	NSH 401 109	(E 06 017 00)
1 off	Suspension clamp SO99, SO86 or ECH12 acc. to page 27		



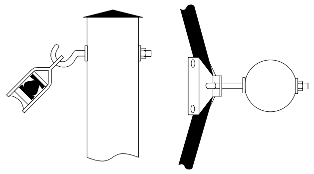
Straight line double

1 off	EBR-kit 0171 (HOOK, bolt washer)	NSH 401 159	(E 06 017 10)
2 off	Suspension clamp SO99, SO86 or ECH12 acc. to page 27		



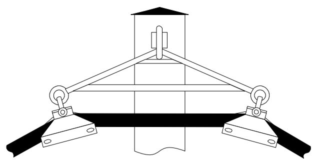
Angle pole, inner angle

1 off	EBR-kit 0170 (Hook, bolt, washer)	NSH 401 109	(E 06 017 00)
1 off	Suspension clamp SO99, SO86 or ECH12 acc. to page 27		



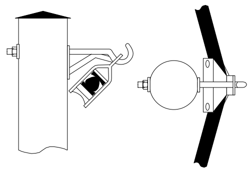
Angle pole, inner angle, max 75º

1 off	Crossarm SOT 73 for double suspension clamp including shackles	NSH 401 119	(E 06 290 34)
2 off	Suspension clamp SO99, SO86 or ECH12 acc. to page 27		



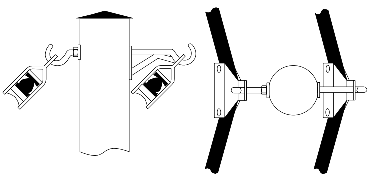
Angle pole, outer angle

1 off	EBR-kit 0172 (Hook, bolt, washer)	NSH 401 108	(E 06 017 20)
1 off	Suspension clamp SO99, SO86 or ECH12 acc. to page 27		



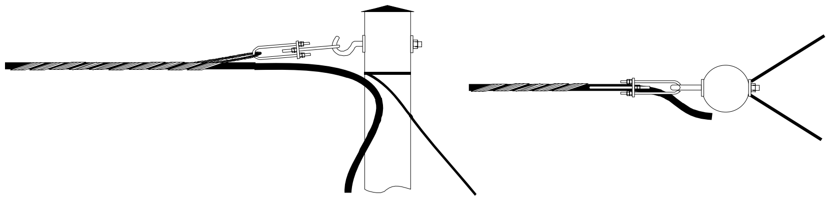
Angle pole, double

1 off	EBR-kit 0173 (Hook, bolt, washer)	NSH 401 160	(E 06 017 30)
2 off	2 off Suspension clamp SO99, SO86 or ECH12 acc. to page 27		



Accessories for EXCEL 3x10/10 and FXCEL 3x16/10

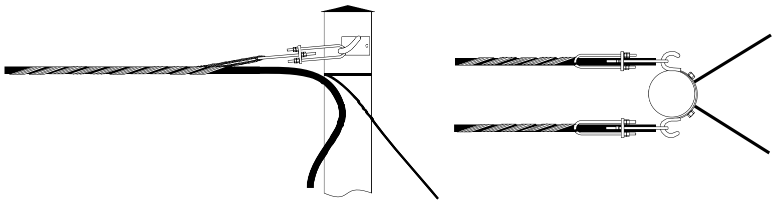
Terminal pole



1 off	EBR-kit 170 (Hook, bolt, washer)	NSH 401 109	(E 06 017 00)
1 off	Dead end spiral acc. to page 28		
1 off	Tension screw 12	NSH 401 138	(E 06 246 70)

Note. The tension screw can be left out if adjusting not is necessary, however assembly and tensioning is easier with them.

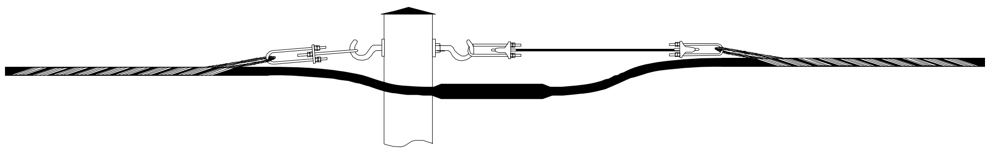
Terminal pole - double



1 off	EBR-kit 174 (Hook, bolt, washer)	NSH 401 161	(E 06 017 40)
2 off	Dead end spiral acc. to page 28		
2 off	Tension screw 12	NSH 401 138	(E 06 246 70)

Note. The tension screw can be left out if adjusting not is necessary, however assembly and tensioning is easier with them.

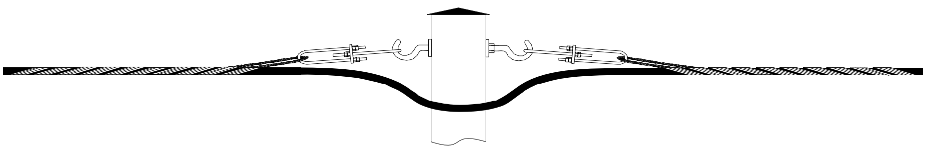
Joint designs



A joint can be made at a pole or in a span. On a pole hooks etc. has to be added.
For selecting joints, joint sleeves etc see page 33.
A joint in a span has to be tension relieved and can be done as below.
The joint shall be positioned 5 – 10 cm under the stay wire so that the tension will be in the wire.

Note. The tension screws can be left out if adjusting not is necessary, however assembly and tensioning is easier with them.

Tension relief- and angle pole (max 5º)

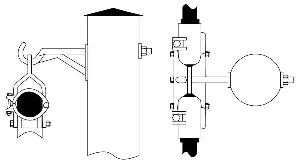


1 off	EBR-kit 171 (Hook, bolt, washer)	NSH 401 159	(E 06 017 10)
2 off	Dead end spiral acc. to page 28		
2 off	Tension screw 12	NSH 401 138	(E 06 246 70)

Accessories for AXCES 3x70/16, 3x70/25 and 3x95/25

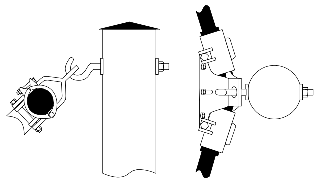
Straight line

1 off	EBR-kit 0172 (Hook, bolt, washer	NSH 401 108	(E 06 017 20)
1 off	Suspension clamp ECH12 or ECH14 acc. to page 27		



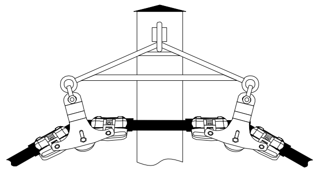
Angle pole, inner angle, max 45º

1 off	EBR-kit 0170 (alt EBR-kit 0172)	NSH 401 109	(E 06 017 00)
1 off	Suspension clamp ECH12 or ECH14 acc. to page 27		



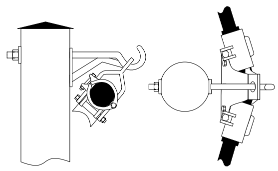
Angle pole, inner angle, max 75º

1 off	Crossarm SOT 73 (incl bolt, shackles)	NSH 401 119	(E 06 290 34)
2 off	Suspension clamp ECH12 or ECH14 acc. to page 27		



Angle pole, outer angle, max 25º

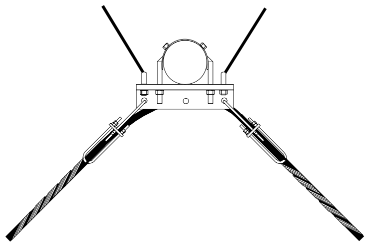
1 off	Hook SOT 74.1 with bolt+nut (M24)	NSH 401 110	(E 06 290 36)
1 off	Suspension clamp ECH12 or ECH14 acc. to page 27		



Tension relief- and angle pole

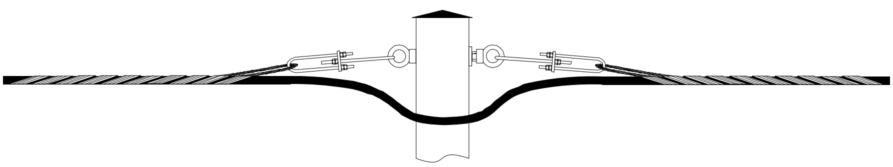
1 off	Short crossarm	NSH 401 111	(E 06 480 15)
2 off	Flat stirrup bolts 20x200	NSH 401 113	(E 06 286 03)
2 off	Wood screw 12x75	-	(E 06 291 48)
2 off	Tension screw 16	NSH 401 116	(E 06 246 71)
2 off	Dead end spiral acc. to page 28		

When pulling out the cable through the angle a suitable pulling roller
Is required.



Tension relief- and angle pole

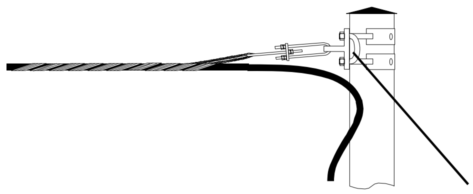
1 off	Stud screw M20 320 mm		(E 06 290 02)
2 off	Lifting eye M20		(E 06 290 25)
2 off	Washer		(E 06 290 10)
1 off	Nut M20		(E 15 620 15)
2 off	Tension screw 16	NSH 401 116	(E 06 246 71)
2 off	Dead end spiral acc. to page 28		

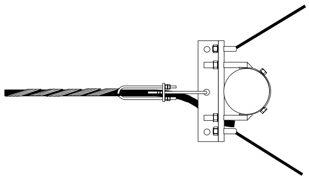


Accessories for AXCES 3x70/16, 3x70/25 and 3x95/25

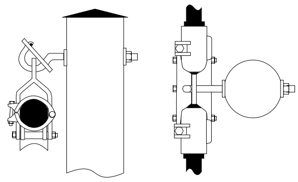
Terminal pole

1 off	Short crossarm	NSH 401 111	(E 06 480 15)
1 off	Dead end spiral acc. to page 28		
1 off	Tension screw 16	NSH 401 116	(E 06 246 71)
2 off	Flat stirrup bolts 20x200	NSH 401 113	(E 06 286 03)
2 off	Wood screw 12x75	-	(E 06 291 48)





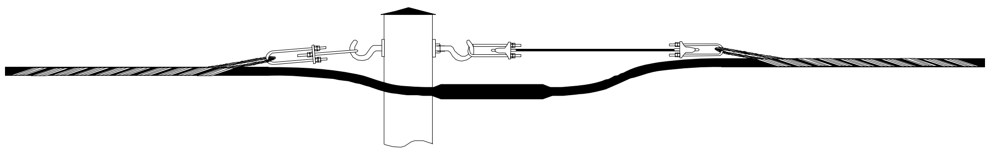
Straight line pole with locked hook



1 off	Hook with locking plate SOT 101.1	NSH 401 186	(E 06 451 28)
1 off	Suspension clamp ECH12 or ECH14 acc. to page 27		

This design is handy when there is a risk of getting lift-up in the suspension clamp when the cable is pulled out.

Joint designs



A joint can be made at a pole or in a span. On a pole hooks etc. has to be added.
For selecting joints, joint sleeves etc see page 33.
A joint in a span can be tensioned or tension relieved and can be done as below.
The joint shall be positioned 5 – 10 cm under the stay wire so that the tension will be in the wire.
The wire must have appropriate strength (52 mm^2)

Note. The tension screws can be left out if adjusting not is necessary, however assembly and tensioning is easier with them.

Note. The tensioned joint must be made with special joint sleeves, see page 33 for details.

Joints, terminations

Joints and terminations from other manufacturers than mentioned below (Raychem/Tyco) can be used provided that they are designed for the cable in case. Observe the diameter over the XLPE insulation of the universal cables that can be different from the diameters of standard XLPE cables. The diameters can be found on pages 49 to 50.

If a tensioned joint in span shall be made the material indicated below **must** be used.

Which joint to use ?

Cable	Joint	NSH-No.	Comments
EXCEL/FXCEL 12 kV	MXSU-3301	NSH 401 197	Complete with screw joint sleeves for conductors and screen.
EXCEL/FXCEL 24 kV	MXSU-5301	NSH 401 198	Complete with screw joint sleeves for conductors and screen.
AXCES 3x70 12 kV	MXSU-3311	NSH 401 199	Complete with screw joint sleeves for conductors and screen.
	SXSU-5312-SE01	NSH 401 201	***Tensioned***. 3 joint sleeves for the conductors and 1 sleeve for the screen acc. to below must be added.
AXCES 3x70 24 kV	MXSU-5311	NSH 401 200	Complete with screw joint sleeves for conductors and screen.
	SXSU-5312-SE01	NSH 401 201	***Tensioned***. 3 joint sleeves for the conductors and 1 sleeve for the screen acc. to below must be added.
AXCES 3x95 24 kV	MXSU-5311	NSH 401 200	Complete with screw joint sleeves for conductors and screen.
	SXSU-5312-SE01	NSH 401 201	***Tensioned***. 3 joint sleeves for the conductors and 1 sleeve for the screen acc. to below must be added.

Joint sleeves

In order to do a tension proof joint with AXCES Pfisterer hexagonal compression sleeves acc. to below must be used. For all other joints screw type joint sleeves or compression type joint sleeves can be used.

when choosing a joint sleeve for the screen it is recommended to select a sleeve one ”size” larger than the actual screen area. For a 10 mm^2 screen use a 16 mm^2 sleeve and for a 16 mm^2 screen a 25 mm^2 sleeve.

Conductor joint sleeves (only for tensioned joints)

Cable	Pfisterer sleeve No.	Comments
AXCES 70 mm^2	301 044 044	Press swage Pfisterer 300 455 458 nr 18 for area 70 (E 08 511 83)
AXCES 95 mm^2	301 045 045	Press swage Pfisterer 300 455 459 nr 20 for area 95-120 (E 08 511 84)

Screen joint sleeves

Screen area	Sleeve area	NSH No.	Comments
10 mm^2	25 mm^2	NSH 401 149	Elpress KSF 25
16 mm^2	25 mm^2	NSH 401 149	Elpress KSF 25
25 mm^2	35 mm^2	NSH 401 150	Elpress KSF 35

Which termination to use ?

Terminations from other manufacturers than mentioned in the table below (Raychem/Tyco) can be used provided that they are designed for the cable in case. Observe the diameter over the XLPE insulation of the universal cables that can be different from the diameters of standard XLPE cables. The diameters can be found on pages 49 to 50.

Terminations for outdoor use is recommended since they have provisions for handling creepage currents which can occur also in moist indoor installations.

Totally enclosed terminations for connection directly to transformers or switchgears can also be used provided that they are designed for the cable and the XLPE diameter of the cable.

Cable	Termination	NSH-No.	Comments
EXCEL/FXCEL 12 kV	OXSU-F3304	NSH 401 151	Cable lugs must be added acc. to below
EXCEL/FXCEL 24 kV	OXSU-F5314	NSH 401 152	Cable lugs must be added acc. to below
AXCES 3x70 12 kV	OXSU-F3324-M	NSH 401 202	Screw type cable lugs included
AXCES 3x70 24 kV	OXSU-F5324-M	NSH 401 195	Screw type cable lugs included
AXCES 3x95 24 kV	OXSU-F5324-M	NSH 401 195	Screw type cable lugs included
AXCES 3x70 36 kV	OXSU-F6332	-	Cable lugs must be added

Cable lugs conductor

Cable	NSH-No.	Comments
EXCEL 10 mm^2	NSH 401 145	Type KRX 10-12 Elpress
	NSH 401 139 + NSH 401 140	Type Cu 25-13 + reduce sleeve Cu 25/10 Pfisterer
FXCEL 16 mm^2	NSH 401 196	Type Cu 16-13 Pfisterer

Cable lugs screen

Cable	NSH-No.	Comments
EXCEL and FXCEL	NSH 401 146	Type KRF 25-12 Elpress
	NSH 401 196	Type Cu 16-13 Pfisterer

Construction instructions

General instructions

The installation of universal cable underground or in water does not differ from "traditional" methods. It is when it is installed as self-supporting aerial cable special considerations have to be made. However the installation method does not differ that much from methods used to install aerial bundle LV cables. Advice and instructions to simplify the installation are given below.

When laid underground conventional methods can be used such as laid in trenches dug into the ground or ploughed in. Of course, care has to be used when handling the cable just as with any medium voltage cables.

When laid in water, traditional bottom examinations or evaluations have to be made. The cable shall be dug down or protected with pipes when going into or up from the water. In streaming water it is neccessary that the cable is fixed, anchorage will then be needed to prevent movement of the cable in the water. All of the universal cables have a density that makes them sink in water without extra weights, extra anchoring is only required in streaming water.

Tools

To simplify the installation, it is recommended to have the following tools:

- Cable stocking intended for actual cable diameter and for pulling forces up to 10kN
- Dynamometer for at least 5kN for EXCEL and 15kN for AXCES™.
- Come-along clamp for actual cable diameter. For AXCES™ the come along clamp has to be approved for 15 kN.
- Rollers for pulling in angles and at long section of lines.

Tools

To simplify the installation, it is recommended to have the following tools:

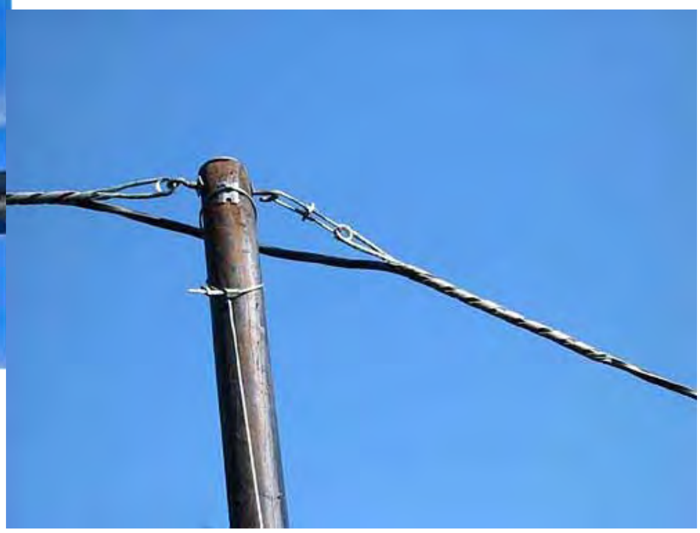
- Cable stocking intended for actual cable diameter and for pulling forces up to 10kN
- Dynamometer for at least 5kN for EXCEL/FXCEL and 15kN for AXCES™.
- Come-along clamp for actual cable diameter. For AXCES™ the come along clamp has to be approved for 15 kN.
- Rollers for pulling in large angles and at long section of lines.

Both steel and Kevlar cable stocking can be used, see instructions below at “Preparation of the cable end”.
The use of a dynamometer is recommended, especially when building AXCES.
A come-along clamp or two makes the erection easier but one can manage with an extra dead end spiral. The spirals can be used many times and they are not as hard to the cable as the come-along clamps.

Suitable come-along clamps for the Universal cables are as per below:

EXCEL 3x10/10, FXCEL 3x16/10 12 kV	NSH 401 120	E 16 571 10
EXCEL 3x10/10, FXCEL 3x16/10 24 kV	NSH 401 121	E 16 571 14
AXCES™ 3x70/16 12 kV	NSH 401 181	E 16 571 17
AXCES™ 3x70/16 24 kV	NSH 401 122	E 16 571 16
AXCES™ 3x70/25 36 kV	NSH 401 122	E 16 571 16
AXCES™ 3x95/25 24 kV	NSH 401 122	E 16 571 16

Using the ECH14 clamp in many cases eliminates the need for separate rollers. Note that the smaller suspension clamps of “ABC-type” has a limited capability when it comes to pulling out long lengths and high pull-out speeds, especially at high temperatures.



Pulling an overhead line

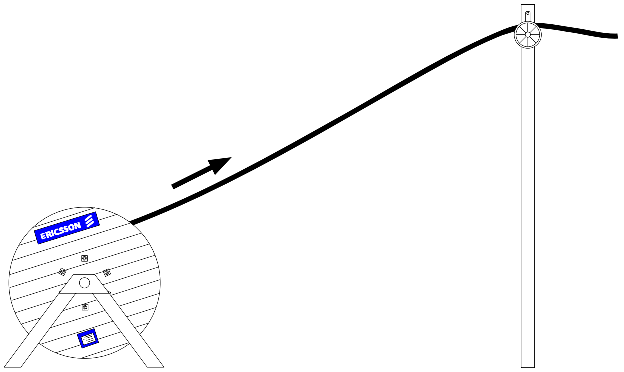
Placement of the drum

The placement of the drum is dependant on a number of circumstances. Transportation of the cable to the required position is of course decisive. It is easier to pull downhill than uphill, therefore place the drum at the highest end if possible. Where there is a very big difference in level it can be difficult to break the drum when pulling downhill.

If there are large angles it is advantageous to have them at the end instead of the beginning.

The cable should be wound from the top of the drum, see figure below.

The cable drum placed on a unroll stand.
A roller can be mounted in the first pole.



It is suitable to have a well-sized roller on the first pole. A constant check should made to ensure that the cable is running out smoothly. Pay particular attention to where there is a change from one cable layer to another.

The drum must never rotate faster than the cable is running out. It is necessary to break the drum when pulling out. Where there is a sudden stop in pulling, the rotation of the drum has to be stopped quickly; otherwise the cable can roll under the drum and get damaged.

Preparation of the cable end

The most critical moment in the pulling out operation is when the cable end and cable stocking passes through the line roller or suspension clamp. To make the pulling out easier the cable end should be "sectioned down" at the end before the cable stocking is applied. Between 150 – 200 mm/core is enough, see figure below.

This will make the end smoother and more flexible when it passes the pulling devices. If a cable stocking of Kevlar is used this is more important as it is soft and does not form a natural cone the same as a cable stocking of steel. The cores can also be cut with a knife to avoid sharp edges, which will simplify the pulling even more.

Fix the end of the cable stocking with some layers of electrical tape. Be careful that there are no unnecessary big knots, eye rings, shackle wire eyes or similar things present that can get hitched during the pulling out. A well prepared cable end will save time as it simplifies the pulling out.

Pulling out

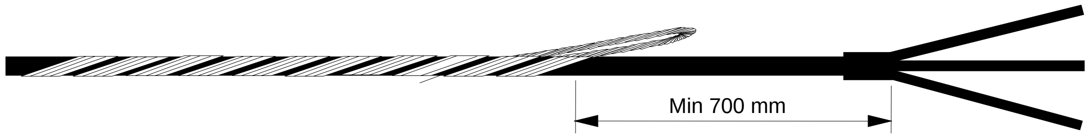
It is recommended that the cable does not come into contact with the ground when pulling out, but this can be difficult to achieve, especially with longer spans. Therefore check the route for sharp objects like blast stones or similar objects. Protection can be laid in advance where required, e.g. boards or scaffold poles.

When pulling out through suspension clamps or separate rollers there must be enough space for the cable with cable stocking. Sometimes it is easier if someone goes along and shakes the cable when the end passes the suspension clamp, the pulling wire has to be stopped before the tension in the wire gets too high. At large angles and at the beginning of long sections of line well sized rollers shall be used to reduce the required pulling forces. Be observant as the pole can twist if it is an outer angle pole.

Mounting at the first terminal pole

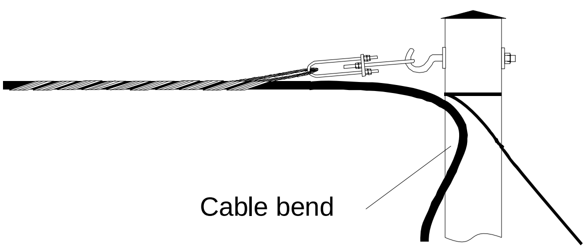
Fitting the dead end spiral and end terminations on the ground then lifting the prepared end up the pole can save time. The dead-end spiral and termination shall be applied according to the manufacturers instructions.

Observe that the distance between the start of the dead-end spiral to the point where the sheath is removed must be at least 700 mm, see figure below. Also where the cable leaves the spiral, ensure a smooth radius is formed to avoid unwanted bends.



The spiral is designed so it can stretch a little after application. This can happen with increased forces, e.g. tree falling on the line or ice loading. It also happens when the dead-end is first mounted at one end of the line and then tensioned up at the other, there will be a stretch in the first mounted end. This means that there must be enough cable to take care of that stretch. If the cable is mounted too tightly there is a risk that the tension forces will be taken up by either the screen termination, end termination or lightning arrestor.

To avoid this the cable shall be mounted with a bend on the cable between the dead-end and the pole. When mounting AXCES™ a come-along clamp and a pulling device at the top of the pole can be used to lift the cable and to get the correct bend in the cable



Tensioning – regulation of the line

Tension the cable with a come along clamp, dead-end spiral or other suitable device that is designed for the cable. Put the come along clamp or spiral at least 1 metre from the cable end, otherwise it could slip.

A suitable roller can be placed on the end pole so that the tensioning can be made from the ground. Tension the cable for a minimum of 15 minutes with a force according to the data in the tables below to reduce the permanent setting in the cable after lying on the drum. Do not tension the cable with full force for more than 2 hours if the come along clamp is on a part of the cable that shall be in service. The come along clamp is dimensioned for short time use and long tensioning with the clamp may damage the cable.

Retension the cable according to the regulation tabels below. Always use a dynamometer.

A practical method to apply the dead-end can be to tension the cable and mark out where the dead-end shall be mounted. Then lower the cable to the ground and mount the dead-end and end termination, after that, lift the cable end onto the pole. Fine adjustment can be done with a tension screw. If the dead-end is mounted on the pole, the wire to the come along clamp can make the mounting more difficult.

Due to the length of the dead-end for AXCES™ it is neccessary to use a sky lift or bridge if the work is to be done up the pole. Ground mounting is recommended, where possible.

REGULATION TABLE

	Temperature at time of installation °C	Force kN	Sag in metres at a **span** length in meters of				
			50	**60**	**70**	**80**	**90**
EXCEL 3x10/10 12 kV	20	2,5	1,0	1,4	1,9	2,5	3,1
	10	2,6	1,0	1,4	1,8	2,4	3,0
	0	2,7	0,9	1,3	1,7	2,3	2,9
	-10	2,8	0,9	1,3	1,7	2,2	2,8
	-20	2,9	0,8	1,2	1,6	2,1	2,7

	Temperature at time of installation °C	Force kN	Sag in metres at a **span** length in meters of				
			50	**60**	**70**	**80**	**90**
EXCEL 3x10/10 24 kV	20	3,0	1,0	1,4	2,0	2,6	3,3
	10	3,1	1,0	1,4	1,9	2,5	3,2
	0	3,2	0,9	1,3	1,8	2,4	3,1
	-10	3,3	0,9	1,3	1,7	2,3	3,0
	-20	3,4	0,8	1,2	1,7	2,2	2,9

	Temperature at time of installation °C	Force kN	Sag in metres at a **span** length in meters of						
			50	**60**	**70**	**80**	**90**	**100**	**110**
FXCEL 3x16/10 12 kV	20	3,8	0,85	1,22	1,66	2,2	2,7	3,4	4,1
	10	3,95	0,81	1,17	1,59	2,1	2,6	3,2	3,9
	0	4,1	0,78	1,12	1,53	2,0	2,5	3,1	3,8
	-10	4,3	0,75	1,08	1,46	1,9	2,4	3,0	3,6
	-20	4,5	0,71	1,03	1,40	1,8	2,3	2,85	3,45

	Temperature at time of installation °C	Force kN	Sag in metres at a **span** length in meters of						
			50	**60**	**70**	**80**	**90**	**100**	**110**
FXCEL 3x16/10 24 kV	20	4,2	1,05	1,51	2,06	2,7	3,4	4,2	5,1
	10	4,3	1,02	1,47	2,00	2,6	3,3	4,1	5,0
	0	4,4	0,99	1,43	1,95	2,5	3,2	4,0	4,8
	-10	4,5	0,97	1,39	1,89	2,5	3,1	3,9	4,7
	-20	4,7	0,94	1,35	1,84	2,4	3,0	3,8	4,5

AXCES™ 3x70/16 12 kV, REGULATION TABLE

Temperature at time of installation °C	Force kN *	Sag in metres at a span length of Normal span length 110 metres						
		60*	80	90	100	110	120	140
20	8,3	0,87	1,55	1,96	2,4	2,9	3,5	4,7
10	8,7	0,83	1,47	1,86	2,3	2,8	3,3	4,5
0	9,2	0,78	1,39	1,75	2,15	2,6	3,1	4,2
-10	9,8	0,73	1,30	1,65	2,0	2,4	2,9	4,0
-20	10,5	0,68	1,21	1,54	1,9	2,3	2,7	3,7

AXCES™ 3x70/16 24 kV, REGULATION TABLE

Temperature at time of installation °C	Force kN *	Sag in metres at a span length of Normal span length 110 metres						
		60*	80	90	100	110	120	140
20	9,1	0,87	1,55	1,96	2,4	2,9	3,5	4,7
10	9,6	0,83	1,47	1,86	2,3	2,8	3,3	4,5
0	10,1	0,78	1,39	1,75	2,15	2,6	3,1	4,2
-10	10,8	0,73	1,30	1,65	2,0	2,4	2,9	4,0
-20	11,5	0,68	1,21	1,54	1,9	2,3	2,7	3,7

AXCES™ 3x70/25 36 kV, REGULATION TABLE

Temperature at time of installation °C	Force kN *	Sag in metres at a span length of Normal span length 100 metres					
		60*	80	90	100	110	120
20	9,4	1,0	1,8	2,1	2,6	3,2	3,8
10	9,8	0,9	1,7	2,1	2,5	3,0	3,6
0	10,3	0,8	1,6	2,0	2,4	2,9	3,5
-10	10,9	0,8	1,4	1,8	2,3	2,8	3,4
-20	11,5	0,7	1,3	1,7	2,1	2,7	3,3

AXCES™ 3x95/25 12 - 24 kV, REGULATION TABLE

Temperature at time of installation °C	Force kN *	Sag in metres at a span length of Normal span length 100 metres					
		60*	80	90	100	110	120
20	9,6	1,1	1,9	2,2	2,8	3,4	4,0
10	10,0	1,0	1,8	2,2	2,7	3,2	3,8
0	10,5	0,9	1,6	2,1	2,5	3.1	3,7
-10	11,0	0,8	1,5	1,9	2,4	2,9	3,5
-20	11,6	0,7	1,4	1,8	2,2	2,8	3,4

***)**
N.B. !
Lines with short spans (~60 meters or less) can give very high forces on poles and stays. In order to avoid this, decrease the tensioning forces compared to what comes out of computer programmes used for pole setting. The increase of sag at these short spans is marginal. Forces in the table below can be used as a recommendation.

Temperature at time of installation °C	Force in kN at 50 m span	
	AXCES 3x70/16 12 and 24 kV	AXCES 3x70/25 36 kV and 3x95/25 24 kV
20	5,5	6,5
0	6	7
-10	6,5	7,5

Difficult lines - steep - long - curved

When constructing lines that are of long section, have many or large angles, have large differences in level or large differences in span lengths there are some experiences to think of.

When pulling out it is important to use rollers with reliable wheels or use a yoke and divide the angle in two parts on poles with large angles. It is of special importance if the angle is at the beginning of the line as the breaking forces "increase" and can make the pulling out too heavy. The end chosen for the pulling out influences the forces required. If possible choose the direction where the angles are at the end of the line.

The smaller combined suspension clamps/rollers type SO99, SO86 and similar are normally designed for a maximum pull out length of 500 metres. This is due to the fact that the wheels are small with a simple bearing and that can make the wheels cut up at long lengths, high speed or high temperature. Use integrated suspension clamp type ECH14 or separate rollers.

It is also important that the suspension clamp or rollers can move freely, especially in outer angles, the wrong hook can make the clamp or roller touch the pole and therefore pitch which will strongly increase the pulling force. If this happens at the beginning of a line it may be impossible to pull out the cable.

One way of solving the problem is when the cable end passes a clamp then, either shake the cable or the pole or pull on the cable with a rope slung over the cable.

With good planning and the right equipment it is possible to pull out over 2000 metres in one length. Where problems are encountered a come along clamp and a winch can be used along the line to support the pulling out by pulling 50 metres at a time in a span.

During final regulation of the line it may be necessary at difficult lines to re-tension at poles along the line with a come along clamp. If there are tension poles along the route with dead-ends the line can be regulated in sections. Tension points are required if there are spans with very different span lengths, the short span will tend to be very straight whilst the long one will have a large sag.

Lines with large differences in level (>100 metres) have to be tensioned with spirals on the way up so that the whole cable weight not will hang on the top and make the force on the top very high and very low at the bottom. Work from the lowest point up to the highest, tensioning and measuring shall be made from the highest point.

Laying in ground and in water

The Universal cables may be buried direct in ground or laid in water, salt or fresh. When laying in the ground the same precautions shall be taken as for any other cable of for example type AXCEL. Because of the high-tension conductors of the Universal cables they are somewhat stiffer than standard ground cables. This might lead to an extra need to press the cable down in the trench.

When laying cable in water it is important that the density of the cable is high enough to make the cable sink. Normally a density of 1.2 kg/dm^3 is sufficient. All Universal cables have densities over 1.2 and are thus suitable for lying in water. The density of each cable can be found in the Technical Descriptions pages in this book.

Where the cable enters or leaves the water it must be protected against waves and ice. Burying down the cable and/or using a protecting pipe of suitable type is preferred.

An inspection of the bottom along the cable route should be done. If necessary the cable should be secured by means of weights or cement sacks or in other ways.

In case of streaming water and the speed of the water is in the order of 2 m/s or more the cable needs to be secured in some way. In all cases the cable must not be moving in the water, if it does it will sooner or later have a failure. An easy way to check for possible damages of the sheath is to perform an electrical test of the sheath insulation.

The depth of laying should not exceed approximately 100 meters, for larger depths contact Ericsson C&I.

Cable handling

In general, the EXCEL/AXCES™ cables are handled in the same manner as other three core XLPE-cables for 12 and 24 kV. What differs is that AXCES™ has a conductor that is made up of aluminium alloy and the pressing of lugs and sleeves has to be made with a system suitable for Al-alloy conductors. Normally a six-sided pressing or screw system with a fixed moment is required.

Due to the strong outer PE shealth in combination with the compact cable design there is a risk of damaging the cores when cutting the sheath with a knife. Be extra observant during this work, heating the sheath can make the job easier. A tool for removing the sheath can be used; these are available from many suppliers.

The insulation screen is an easy strip type and we do recommend stripping as the method of removing. A special turning tool can be used if preferred but the tool must be in good condition and the craftsman must have the skill to handle the tool. Today there are tools available for even EXCEL 12 kV with its small diameter core.

Maintenance

In general a universal cable line requires less maintenance than a bare or covered conductor line. As the trend is heading towards maintenance managed by need rather than by time, this has an influence on the use of universal cables. As the universal cable is fully screened and insulated, a cable lying on the ground is not the same danger to life as a bare or covered conductor on the ground.

If it is found during an inspection after a storm or at a normal routine inspection, that there are trees or branches lying against the cable, they should be removed. If there have been heavier trees lying on the cable it is recommended to inspect the cable for outer damage and if the heavy trees have been close to a pole or dead-end, inspect the cable for damage in the suspension clamp or dead-end. If the cable has slipped in the suspension clamp the line will have to be re-regulated. After heavy trees have fallen on EXCEL the cable can have a little elongation. That elongation can be distributed in a few adjacent spans, should that not be enough, spirals could be used at a pole to regulate the cable.

Branches lying against the cable must be avoided, as after a period of time the branches could rub through the sheath and cause a short circuit, (compare with ABC cables). Branches and trees growing under the cable shall therefore be removed.

Experiences from use

General experiences from use of the universal cables don't differ from those of our normal XLPE-cables for medium voltage. The cables are designed in the same way from an electrical point of view. If joints and terminations are made in the same proper way as for other cables, no problems can be foreseen during the lifetime of the cables.

When installed in an overhead line situation it is important that the correct accessories are used and that all the recommendations are followed. It is essential to follow design and construction instructions to guarantee problem free use.

Tree falls

At heavy tree falls, as on the adjacent picture, EXCEL will go down to the ground and have some elongation if the fall is a few spans away. The cable can slip in the suspension clamps and after removal of the trees the line has to be re-regulated. The elongation can be spread out in adjacent spans or be taken care of with spirals at a pole. If the tree fall is close to a pole or close to the terminal or section pole there is a risk that the EXCEL cable can break.

A tree fall on AXCES™ normally doesn't mean that the line has to be re-regulated, the cable will have no permanent elongation and it is normally enough remove the fallen trees. A visual inspection of the cable must be carried out to ensure that there is no damage on the outer sheath. It is especially important to inspect after heavy tree falls, close to suspension clamps or dead end spirals.

As long as the cable shows no outer damage it can be assumed that the inner active part is also undamaged. After a cable break, elongation of the conductors is only a small percentage whereas the insulation always stretches; this makes a break very local and leaves the rest of the cable undamaged.

Break points for EXCEL and AXCES™. Break points are localized.

In a case where the cable has broken, a joint can be made, either in the span or at a pole. For a joint in the span EXCEL has to be relieved with spirals and a wire. For AXCES there are tension-proofed joints available but tension relieved joints as in the picture below is easier to do. It can often be more practical to change one span and make the joints at the nearby poles, relieving the cable with spirals in both directions.

AXCES™ with a tension relieved joint in the span.

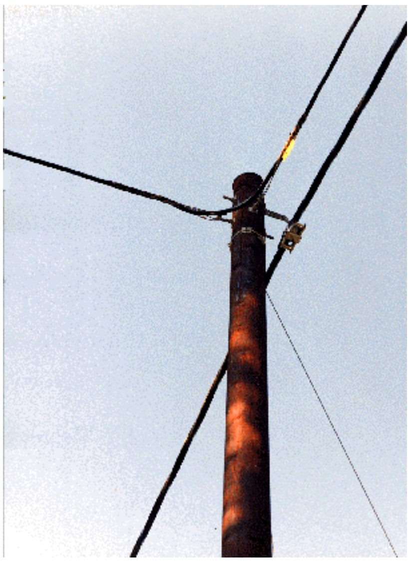
Safety - Standards

From a safety point of view a universal cable system can be compared with a conventional underground cable system. The cables are fully insulated and can be touched without any risk. Protection against mechanical damage must be used where the cables leaves ground, e.g. up onto a pole, in the same way as for traditional underground cables.

The big difference compared with alternative systems such as bare or covered overhead conductors is that the universal cables are fully screen protected. A cable lying on the ground is of no risk and if the cable should break there will be a short circuit to screen, which will cause a disconnection.

In the Standards, universal cables are treated the same as conventional underground cables with the exception when used as self-supporting aerial cable. In national standards and specifications, information can be found relating to the use of cable in overhead lines. From the Swedish Standard some points can be mentioned:

- Lowest height over ground for non-planned areas is 4.5m.
- Lowest height over ground for planned areas is 6m.
- Stay insulators are not required if only a universal cable is installed. If an ABC cable is mounted on the same pole, stay insulators may be required.
- Marking of EXCEL/AXCES™ and ABC are required at every pole.



Spare cable

EXCEL 3x10/10 12 kV is a cable with a weight of less than 1 kg/metre and has a small outer diameter for a medium voltage cable. Together with the very tough mechanical design this makes the cable very suitable as a spare cable for using when temporary connections are required.

This can be, for example, at fault on another cable or a damaged overhead line. Other possible uses are temporary connections at construction activities or as a by-pass when an overhead line is changed to cable.

Supplying electricity in a safe manner to construction areas can be difficult with LV due to routes and distances. A better solution can be to put a temporary transformer that is fed by an EXCEL cable from a 12 or 24 kV line.

At such occasions the cable can be temporarily installed and it is not necessary to use dead end spirals or suspension clamps.

It is practical to have the cable on a drum with a long (15-20 metre) inner end, with the terminations mounted on the cable ends. This provides the opportunity to connect the inner end to a pole or transformer without rolling out all cable from the drum.

Example of a spare cable on a drum with a long inner end.

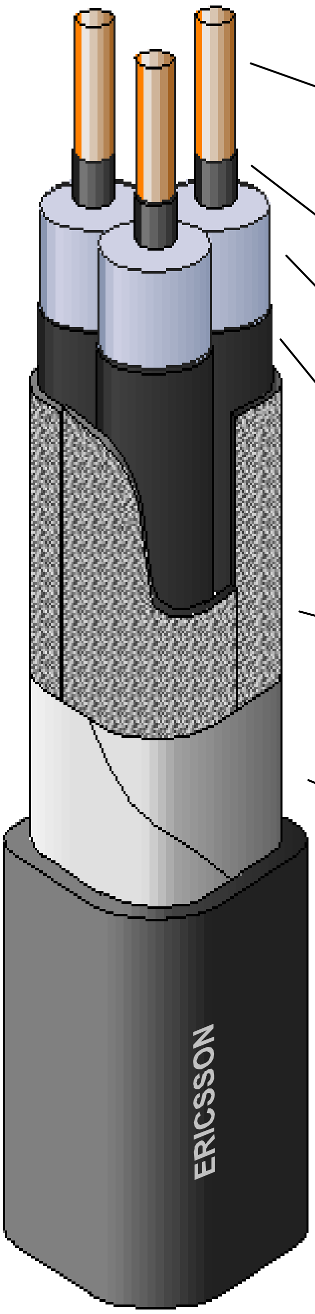
If there is a lot of cable left on the drum the current carrying capacity will be reduced, as the cooling will be worse. A recommended maximum load is:

- Fully rolled out in air with a 25ºC ambient temperature - 90A, as self-supporting 71A.
- With 500 metres on the drum, 15A at 20ºC ambient temperature.

Less cable on the drum provides a higher carrying capacity as well as a lower ambient temperature. A full drum can be loaded with 25A for 5-6 hours.

EXCEL 12 kV is type tested at voltage levels for 24 kV cables and can therefore be used even on a 24 kV network or a mixed network with both 12 kV and 24 kV

Technical description of Universal cables EXCEL/FXCEL and AXCES™



Conductor of copper, solid, hard drawn (EXCEL)
Copper, stranded, hard drawn (FXCEL)
Aluminium alloy (Al59) (AXCES™)

Conductor screen, extruded.

Insulation of XLPE. Dry cured.

Insulation screen, extruded. Easy strippable type.

Screen of woven bands of copper threads,
tinned to avoid corrosion.

Banding

Sheath of black LLD PE, abrasive resistant.
Colour black.
Embossed: "ERICSSON AC3 EXCEL
12kV 3x10/10 (Year of manufacture)"
meter marked.

Designed and tested acc. to IEC60502 and
SS 424 14 16 (HD 620 S1 + A1 part 1, sect. 6M) where app.

Dimensions and weights EXCEL and FXCEL

	Units	EXCEL 3x10/10 12 kV	EXCEL 3x10/10 24 kV	FXCEL 3x16/10 12 kV	FXCEL 3x16/10 24 kV
Conductor diameter	mm	3,55	3,55	4,7	4,7
Nominal insulation thickness	mm	3,4	5,5	3,4	5,5
Diameter over insulation	mm	11	15	12	16
Thickness of sheath	mm	2,2	2,6	2,2	2,6
Diameter (”cable dia”)	mm	29	38	31	40
Diameter (circumferential)	mm	31	41	33	43
Weght	kg/m	0,83	1,18	1,04	1,4
Density	kg/dm^3	1,4	1,2	1,45	1,3

Electrical data EXCEL and FXCEL

	Units	EXCEL 3x10/10 12 kV	EXCEL 3x10/10 24 kV	FXCEL 3x16/10 12 kV	FXCEL 3x16/10 24 kV
Conductor area	mm^2	10	10	16	16
Screen area	mm^2	10	10	10	10
Nominal voltage U_0/U_M	kV	7/12	14/24	7/12	14/24
Rated currents - as self susp. aerial cable (at 25°C air temperature) conductor temp. 65°C	A	71	71	85	85
- in the ground or in water (at 15°C surr. temperature) conductor temp. 90°C	A	90	90	105	105
Cond. resistance, max at 20°C	Ω/km	1,83	1,83	1,15	1,15
Screen resist., max at 20°C	Ω/km	2,0	2,0	2,0	2,0
Max short circ. curr. (1 sek)	kA	2,0	2,0	3,0	3,0
Capacitance	µF/km	0,13	0,10	0,16	0,11
Earth fault current	A/km	0,74	1,14	0,90	1,25
Inductance	mH/km	0,42	0,49	0,40	0,48

Installation of EXCEL and FXCEL

	Units	EXCEL 3x10/10 12 kV	EXCEL 3x10/10 24 kV	FXCEL 3x16/10 12 kV	FXCEL 3x16/10 24 kV
Minimum bending radius (approx.)	mm	250	330	260	330
Min. temperature at laying	°C	-20	-20	-20	-20

Dimensions and weights AXCES™

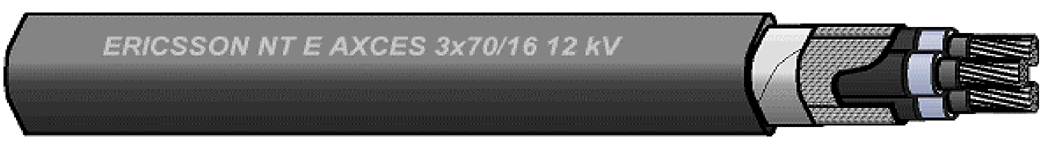
	Units	AXCES 3x70/16 12 kV	AXCES 3x70/16 24 kV	AXCES 3x70/25 36 kV	AXCES 3x95/25 24 kV
Conductor diameter	mm	9,9	9,9	9,9	11,6
Nominal insulation thickness	mm	3,4	4,5	5,5	4,5
Diameter over insulation	mm	17	19	21.8	20,4
Thickness of sheath	mm	2,4	2,6	2,6	2,8
Diameter (”cable dia”)	mm	41	45	52	49
Diameter (circumferential)	mm	44	49	56	53
Weght	kg/m	1,5	1,8	2,1	2,2
Density	kg/dm^3	1,35	1,25	1,2	1,25

Electrical data AXCES™

	Units	AXCES 3x70/16 12 kV	AXCES 3x70/16 24 kV	AXCES 3x70/25 36 kV	AXCES 3x95/25 24 kV
Conductor area	mm^2	70	70	70	95
Screen area	mm^2	16	16	25	25
Nominal voltage U_0/U_M	kV	7/12	14/24	21/36	14/24
Rated currents - as **self susp. aerial cable** (at 25°C air temperature) conductor temp. 65°C	A	160	160	160	200
- in the ground or in water (at 15°C surr. temperature) conductor temp. 90°C	A	190	190	190	240
Cond. resistance, max at 20°C	Ω/km	0,443	0,443	0,443	0,320
Screen resist., max at 20°C	Ω/km	1,2	1,2	0,8	0,8
Max short circ. curr. (1 sek)	kA	8	8	8	11
Capacitance	µF/km	0,29	0,21	0,19	0,25
Earth fault current	A/km	1,8	2,7	3,7	3,3
Inductance	mH/km	0,30	0,33	0,35	0,32

Installation of AXCES™

	Units	AXCES 3x70/16 12 kV	AXCES 3x70/16 24 kV	AXCES 3x70/25 36 kV	AXCES 3x95/25 24 kV
Minimum bending radius (approx.)	mm	360	390	430	430
Min. temperature at laying	°C	-20	-20	-20	-20



Drum tables

The length of cable that can be laid on a drum depends on many factors. Most important are of course the drum size and the diameter of the cable but the acceptable clearance and how well the cable is laid also affects the amount of cable the drum can hold. The clearance is the amount of space between the ground and the cable when the drum is placed on even ground. Standard clearance is recommended in order to minimise the risk of damage to the cable during transport and handling. Clearance equal to cable diameter gives more cable on the drum but also demands more care when handling the drum.

The tables below gives the amount of cable, in meters, that can be laid on different drums for all universal cables. For FXCEL, use the same length as EXCEL. The weight increases with about 18 kg for each 100 meter of cable.

Type of cable	Drum size								
	K16			K18			K20		
	Clearance		Total weight kg	Clearance		Total weight kg	Clearance		Total weight kg
	Standard	Cable dia		Standard	Cable dia		Standard	Cable dia	
EXCEL 12 kV	920	1050	980/1090	1180	1320	1240/1360	1412	1789	1540/1860
EXCEL 24 kV	445	540	740/850	600	600	970/970	830	830	1350/1350
AXCES 70-12 kV				480	580	890/1020	640	770	1200/1380
AXCES 70-24 kV				440	440	1000/1000	590	590	1380/1380
AXCES 95 & 70-36 kV							460	570	1350/1600

Type of cable	Drum size								
	K22			K24			K26		
	Clearance		Total weight kg	Clearance		Total weight kg	Clearance		Total weight kg
	Standard	Cable dia		Standard	Cable dia		Standard	Cable dia	
EXCEL 12 kV	1900	2108	2030/2200	2540	3000	2680/3070	3550	4150	3900/4430
EXCEL 24 kV	1030	1190	1670/1860	1350	1510	2170/2370	1930	2370	3260/3800
AXCES 70-12 kV	820	960	1520/1710	1100	1260	2010/2220	1630	2040	3100/3650
AXCES 70-24 kV	630	750	1520/1740	890	1020	2070/2320	1300	1470	3170/3480
AXCES 95 & 70-36 kV	600	730	1750/2010	850	990	2400/2700	1260	1430	3680/4060

Type of cable	Drum size					
	K28			K30		
	Clearance		Total weight kg	Clearance		Total weight kg
	Standard	Cable dia		Standard	Cable dia	
EXCEL 12 kV	5000	6100	5460/6400	7200	8100	7510/8250
EXCEL 24 kV	2620	3140	4380/5020	3840	4480	6050/6830
AXCES 70-12 kV	2260	2750	4240/4900	3300	3600	5830/6200
AXCES 70-24 kV	1870	2310	4460/5230	2570	3100	5860/6780
AXCES 95 & 70-36 kV	1830	2050	5200/5700	2530	2780	6930/7500

Summary of performed tests

Below are references to some of the electrical and non-electrical tests performed on the Universal Cable system EXCEL and AXCES. Test protocols are available at Ericsson Network Technologies for inspection and in many cases copies of the protocols can be requested. In addition to the referred tests a great number of developing tests have been made internally.

Electrical tests

- Type test according to Swedish Standard SS 424 14 17.

  Test performed on 12kV EXCEL 3x10/10 cable but with voltage levels corresponding to 24kV cable.

  Result: The cable passed the test successfully. (Ref. 604772E)

- Type test according to Swedish standard SS 424 14 17.
  Test performed on 24kV AXCES™ 3x95/25 cable.

  Result: The cable passed the test successfully. (Ref. 604808E)

- Field ageing of EXCEL 3x10/10 12kV cable in a 24kV utility network.
  The cable was laid in water. It has been in service with double nominal voltage for 4 years.

  Result: The cable was unaffected by ageing. The breakdown voltage was higher than 31 x U_o , corresponding to 216-240 kV phase-earth. (Ref HSP566)

- Nail spiking tests on cables EXCEL 3x10/10 and AXCES™ 3x95/25 at Falcon Laboratory, England
  A steel nail was driven through the cable and a short circuit current of 3kA was applied to the cable.

  Result: The screen design proved to withstand the short circuit currents without more than local damage. (Ref. Falcon Testing Laboratory report No. 6616)

- Impulse current test on EXCEL 3x10/10 12kV at NEFI labs in Norway.
  Short circuit tests with currents of up to 10kA RMS at various lengths of cable.

  Result: The cable is self-protecting when the cable length is more than about 500 metres for 12kV and more than about 1000 meters for 24kV cable. Shorter cable lengths should be protected with, for example, fuses. (Ref. 0360-keo604826)

- Investigation of allowable current in cable EXCEL 3x10/10 12kV when the cable is on a drum.
  500 metres of cable was applied on a K14 drum. Current was applied to the cable and the conductor temperature was measured.

  Result: For continuous duty the maximum current with cable on a drum is about 25 amps. Higher current can be allowed for shorter times. (Ref. HSP553)

Except for the tests mentioned above a number of accelerated ageing tests are being performed.

Non-electrical tests

- Test with cable EXCEL 3x10/10 12kV subjected to tree falls until cable breaks.
  The cable was measured before and after it was subjected to several trees until it broke.
  Pd-measurement was made on the two remaining cable parts (except for a short piece at the break).

  Result: The two cable parts were fully operable after the tests and no increase in pd-level was observed. (Ref. HSP385)

- Test on cable AXCES™ 3x95/25 24kV hung in air with increased tension and increased conductor temperature.
  The cable was investigated both electrically and mechanically after the long time test with higher temperature and force than nominal.

  Result: The cable withstood the test. (Ref. 606226)

- E-module measurement on cable AXCES™ 3x95/25 24 kV.
  For use in regulation tables the e-module of the cable has been measured and calculated.
  (Ref. 604817)

- Mechanical measurements on cables EXCEL 3x10/10 12kV and 24kV in a span.
  The cables were hung in air and subjected to different forces, ambient temperatures, conductor currents and simulated ice-loads.
  Sag and e-modules was measured and calculated. (Ref. 604779)

- Static testing of suspension fixture with integral cable pulley type ECH14
  Test performed at Daltek Probator AB.
  (Ref . Test Report No. 990135)

References

[1]
”Evaluation of Performance of AXCES and EXCEL Cable at the Shetland Test Site”
EA Technology Report No. 5039, October 1999

[2]
” Severe weather testing of AXCES cable at Deadwater Fell”
EA Technologies Services Report T3550, November 2001

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