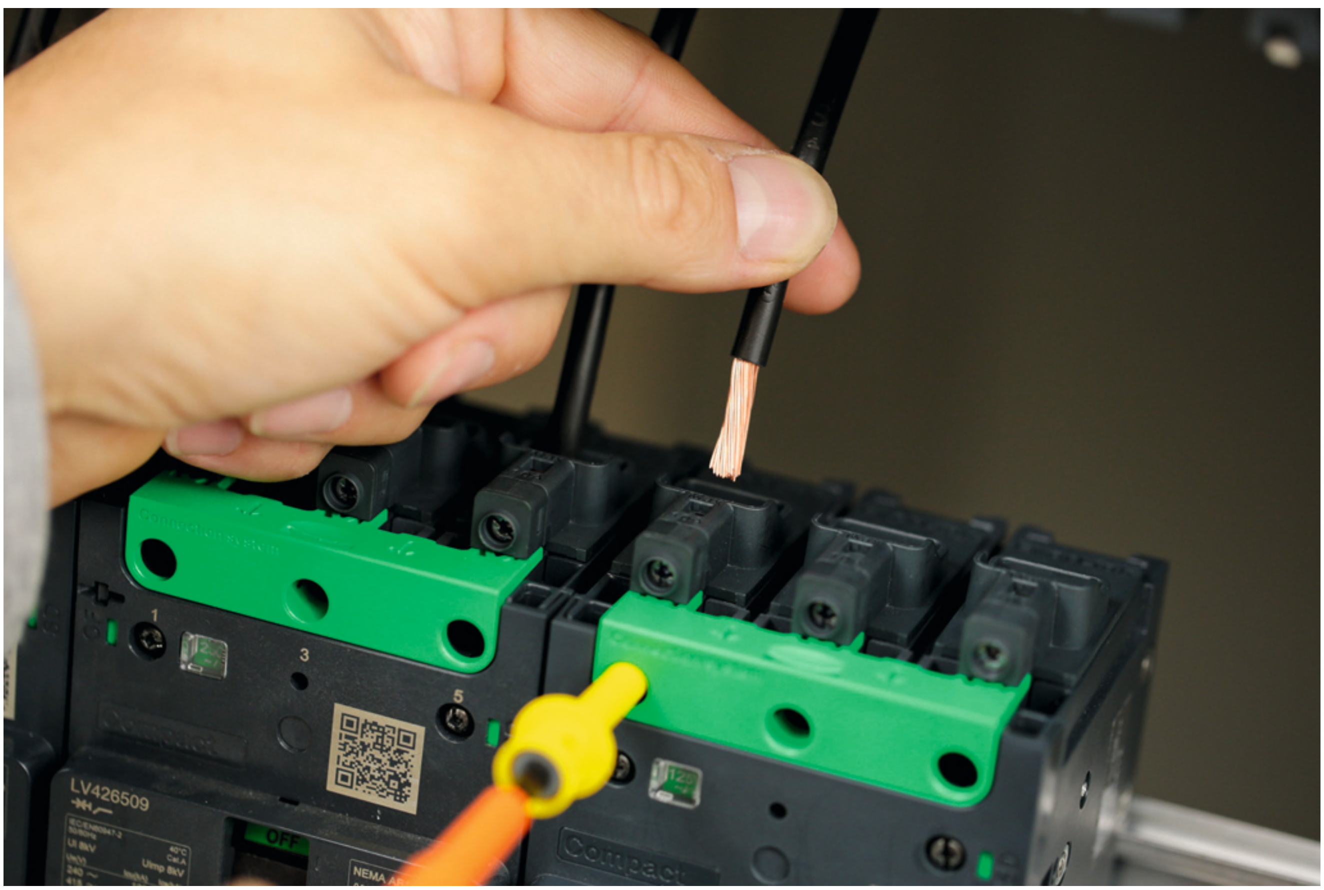
How to ensure a secure, long-lasting power connection for your electrical installation

by Emir Boumediene and Daniel Vanzetto
Date: Feburary, 2018

Executive summary

This white paper is based on the subject of power connections in electrical installations. It considers the importance of a reliable connection in terms of protecting electrical installations from the risk of electrical fires, and outlines how the effect of cable creeping contributes to this risk. Finally, this paper discusses how Schneider Electric's EverLink™ technology ensures a reliable, long-lasting connection by mitigating the loosening effects of heat cycling or vibrations.

Summary



1. Introduction

Power connections are the basis of electrical installations. As the prime interface for our customers, power connection safety and reliability is not just advisable, it's essential. Furthermore, reliable connections are critical in terms of protecting installations against electrical fires, which can inadvertently start as a result of poor or loose connections. A number of factors can contribute to the issue of faulty connections. One of them is the creep effect on cables - which results in the loss of pressure in power connections.

Schneider Electric's EverLink™ is a creep-compensating technology that mitigates the loosening effects of creeping. This paper discusses the effects of creeping and how EverLink technology protects customers from its associated risks, to ensure a reliable and long-lasting connection.

2. Background

Given that safety, maintenance and reliability are the most important priorities for electrical installation power connections, it is no surprise that the 'creep effect' is an important consideration for facility managers who are looking to maintain their power cables in optimal condition.

Creep is a state in which cable material begins to deform when submitted to stress. High and low temperature cycles have the effect of increasing the creep in cable materials due to their viscosity properties. In a worst-case scenario, creep can be the cause of electrical fires and other electrical-related damage.

In the domain of electrical distribution, power connections are either screw-in or screwless. The main difference between the two standards relates to the force exerted on the cables by the connecting force. As we will see below, each has their advantages and disadvantages that should be taken into consideration when choosing circuit breakers.

2.1 Screw-in connections

Figure 1

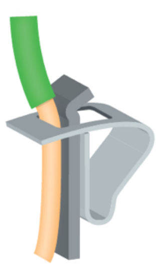
View of screwed-in connection

With screw-in connections, the force comes from a threaded element like a screw or a bolt. The main advantage of screw-in connections is that a substantial force can be applied on conductors - which gives a good spreading and compacting of cables, and thus, a lower contact resistance. Moreover, screw-in connections offer an incoming space that is big enough to plug in several cables. However, screw-in connections can be sensitive to vibrations, which can lead to overheating and thus cable creeping. This means that it is necessary to regularly re-tighten power connections in order to minimize the risk of potential incidents arising as a result of loose connections.

2.2 Screwless connections

Figure 2

View of a Screwless connection



With screwless connections on the other hand, the force originates from a spring element, such as spring blades or elastic jaws. The force exerted by screwless connections is usually less than the force from a threaded element for the same connection. One of the drawbacks of screwless connections is the limitation of having only one cable per connection. The main advantage of this type of connection is the constant force over time on the cable, no matter the level of creep associated with the cable.

2.3 Connection constraints

Power connections can be subjected to a range of negative effects which can adversely impact their behavior: micro-motions due to vibrations, thermal dilatations, or the creep phenomenon all tend to increase contact resistance due either to surface oxidation during relative motion or lower contact pressure. We will examine the creep phenomenon over the following pages.

3. What is creep?

3.1 Cause and physical parameters

Metals such as copper and aluminum, which are commonly used in cables, are considered elasto-plastic, however, they are subject to delayed permanent deformations under particular conditions of stress, temperature, even if the load generates stresses lower than yield stress.. Creep is a state in which a material, subjected to permanent and constant stress, begins to deform permanently over a period of time. High and low temperature cycles have the effect of increasing the creep in materials due to their viscosity properties - indeed, extreme temperatures can modify the material structure. In summary, time, mechanical stress and temperature are all factors that affect the behavior of cables.

To illustrate this point, imagine a shelf stacked with books on it. After a period of time, under the combined load of the weight of the shelf and the weight of the books, the shelf will bend, even though the load is lower than the material elastic limit.

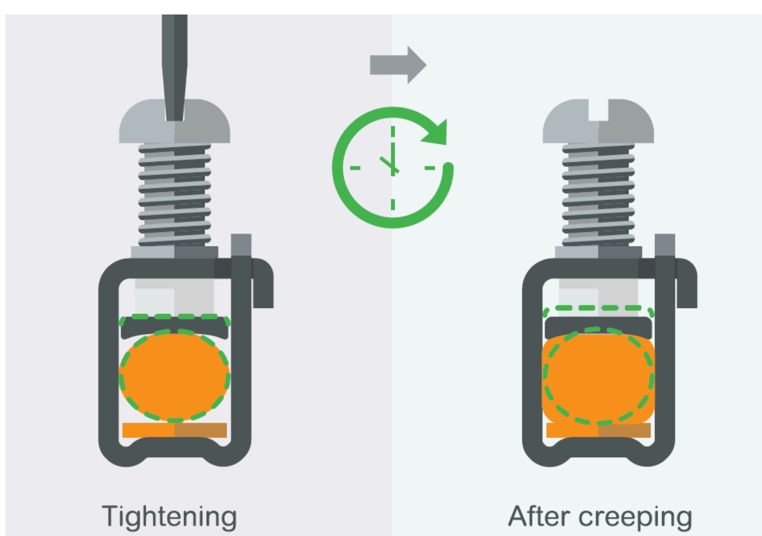
Figure 3

Effect of time and load on shelf with books

In general the creep impact has a direct relation with the diameter of the cable; the thicker the cable, the greater the effect of creep. With electrical connections, a slight change in the cable shape may lead to lower contact pressure, which gives cause for concern. Furthermore, in electrical cables, especially flexible cables, another phenomenon occurs: the various wires within the cable rearrange themselves in such a way that they occupy the entire available space, due to the force applied on them. See Figure 4 illustrated below:

Figure 4

Expansion of cables due to creep

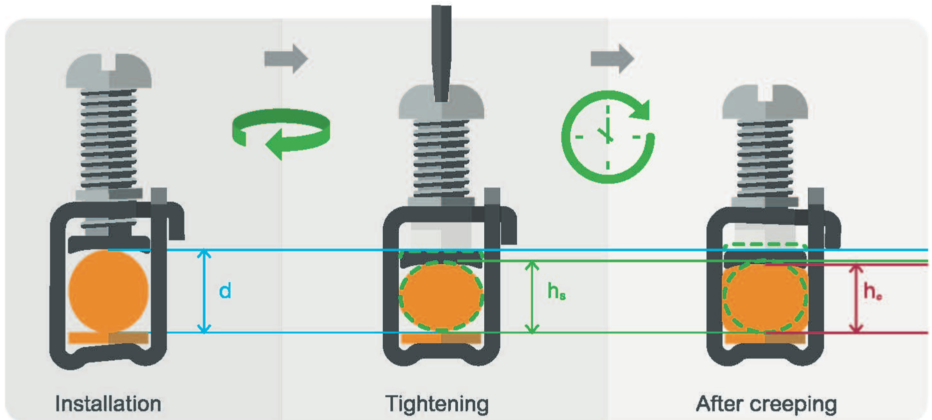


3.2 Impact on assets

It is worth mentioning that a screw-in connection features several key parameters that ought to be taken into account: materials, cable size, screw, and lug. After tightening, the torque applied will be converted into force and the rotation will be converted into translational displacement of the screw plate, resulting in a final height.

Figure 6

Effect of screwing in a connection



The diameters of the wires illustrated above are linked to permanent deformation as a result of elastic deformation, (which is reversible), and plastic or creep deformation, (which is permanent) of the cable.

The initial diameter is illustrated above, (see cable diameter d).
After screwing, the diameter becomes H_s due to the initial compression of the cable. Finally, over time the cable is subject to creepage and the final diameter is H_c.

Standard lugs connections are prone to creeping because the only elastic reserve in the assembly is "stored" in the lug itself. However, maximum deformation inside the cable is the sum of permanent deformations (plastic during tightening and creep deformations), in addition to elastic deformations which are reversible. When the force is reduced, the cable releases the elastic deformations only, so the force may not be sufficient to ensure correct contact pressure.

4. EverLink solution

4.1 Overview

EverLink is a technology that offers customers reliable, tightened cables over a long-term duration to ensure a secure and reliable power connection. The EverLink solution is achieved by the user tightening the lug around the cable and loading a spring which compensates the loss of space due to the effect of creeping, as we have seen previously.

Introduced in 2007 for the Schneider Electric TeSys range, this patented technology is available in two formats:

- A spring blade is added to the lug (TeSys for instance, applied for two cable lugs, allowing a longer stroke for the spring effect).
- The lug itself incorporates a special feature for the spring effect - this creates compactness for shorter lugs.

This spring effect replicates the behavior of screwless connections, which are creep-compensated, while providing a high level of pressure between cable and product connection, and thus, a lower contact resistance.

4.2 Physical principles

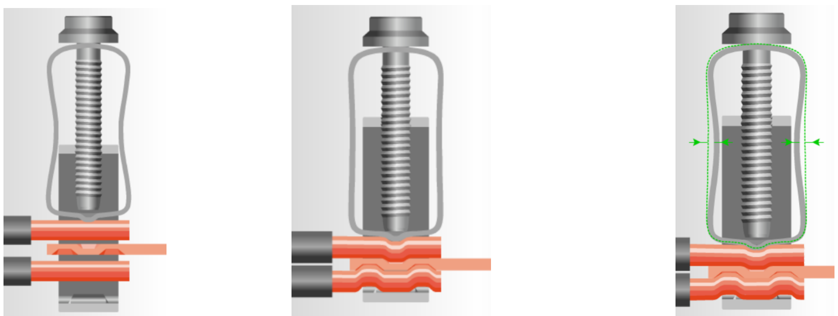
4.2.1 EverLink - with TeSys

With this technology, the spring effect is stored in an elastic element that surrounds the screw, which deforms during tightening, transforming from an incurved shape (Figure 7-a) to a straight one (Figure 7-c).

When the cable starts to creep, the elastic part tends to revert to its initial shape and provides sufficient pressure to avoid thermal runaway or other hazardous installation effects.

Figure 7

Working principle of EverLink TeSys



a- Initial b- Screwed in c- Creep

Creep compensation is achieved as a result of the specific spring effect design.

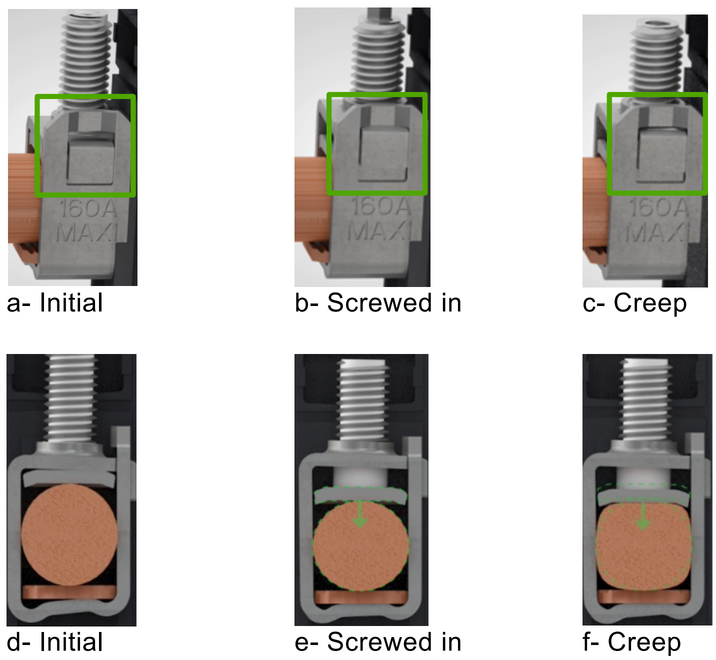
4.2.2 EverLink - with Compact NSXm and PowerPact B

With this technology, the lug behaves slightly differently. Its shape is neither square nor rectangular but rather trapezoidal. Furthermore, the lug has an area of relative motion which allows elastic deformation before reaching the stop. From this position, the stiffness of the lug is similar to that of a regular lug.

Initially, the lug is in the bottom position (Figure 8-a). After screwing, it reaches the upper position (Figure 8-e) while the lug is being loaded, (shape changes from trapezoid to square). Once the begins to creep, the lug should revert to its initial position, whilst maintaining pressure on the cable (Figure 8-f).

Figure 8

Working principle of EverLink for PowerPact B and Compact NSXm



4.3 Circuit breaker connection test

In November 2017, Schneider Electric's test laboratories carried out comprehensive tests in which it compared three similar (160A) molded case circuit breakers to measure the effects of connection unscrewing. The circuit breakers tested were Schneider Electric's Compact NSXm, as well as circuit breakers from two leading competitors.

The objective of the tests was to measure the level of heat generated on the terminal of each circuit breaker as a result of unscrewing the connection of each, (thus emulating the cable creep and unscrewing effect caused by vibrations), at intervals of quarter turns up to a maximum of 1.25 turns. Each of the three circuit breakers was subjected to the same test in identical conditions.

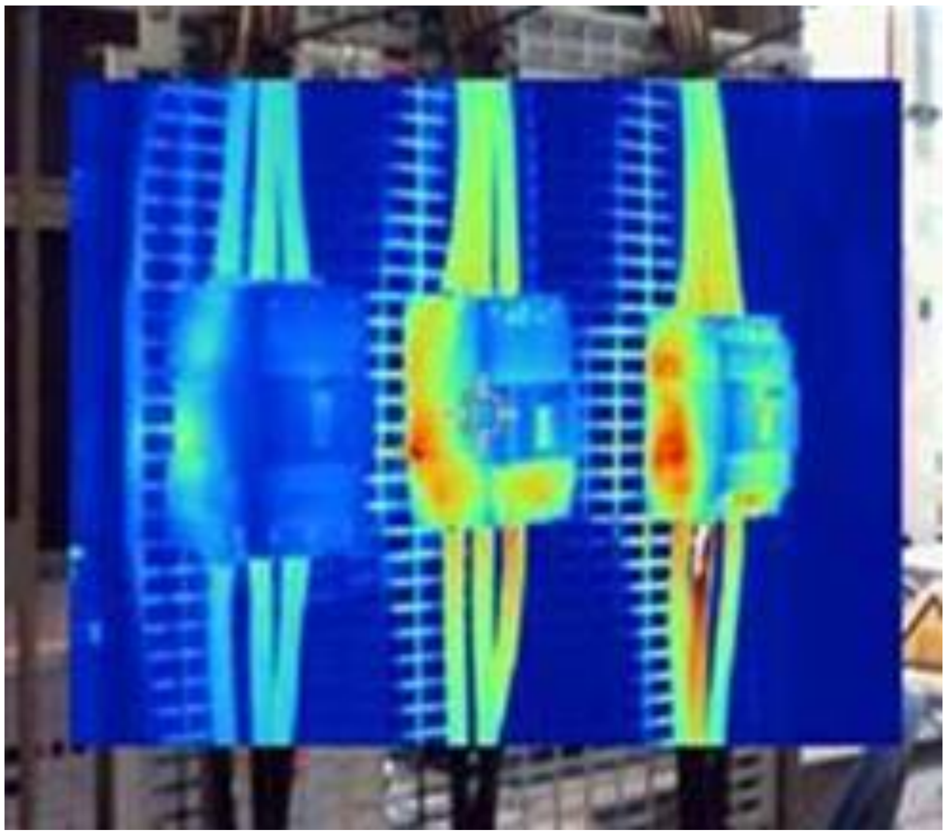


Figure 9

Thermal analysis image featuring Compact NSXm (on left) alongside two leading competitors (to the right) after unscrewing by a half turn

The results of the testing concluded that Schneider Electric's Compact NSXm molded case circuit breaker outperformed the competition. That's to say, during testing, the Compact NSXm breaker generated the least heat of the three circuit breakers, by some margin, and as a result was the only one that did not trip after one complete screw turn. The competitors' products no longer maintained sufficient pressure on the wire and therefore tripped when unscrewed by over a half turn.

A study was done in parallel with TeSys GV4 motor circuit breaker and two leading competitor showing similar findings. These studies thus showed the resounding strength of the EverLink power connection technology across both the Compact NSXm and TeSys range.

4.4 Benefits of EverLink

Safety
EverLink ensures a more reliable connection by providing a spring pressure reserve on cables in the event of thermal dilatations, creeping, or loosening as a result of external vibrations.
This pressure reserve maintains the connection in a wide range of operational environments by ensuring lower contact resistance, and thus, a lower temperature rise. Not only does this reduce the risk of thermal runaway, which can potentially lead to a fire, it also diminishes the risk of the cables being pulled out of their power connections during a short circuit.

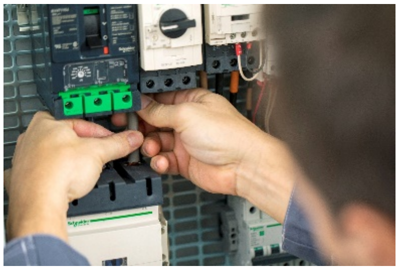
Maintenance
As EverLink's spring effect ensures the tight connection over the time, retightening campaign are no longer required each year. This frees up time for maintenance technicians who traditionally have had to invest more time in this type of preventive maintenance. Furthermore, where thermal camera are used according to local regulations, the facility managers can have peace of mind knowing that the EverLink connections have creep compensating technology.

Continuity of service
When there is a creep effect present, in certain cases, the excessive heat generated at the connector can be detected by the thermal overload protection (bimetallic strip) causing the circuit breaker to trip. This unwanted trip could potentially halt a continuous process leading to raw material scrap or loss of productivity. As seen in the circuit breaker connector test, the leading competitors without EverLink technology, inadvertently tripped due to the connectors overheating. It is time consuming for the maintenance technicians to manually reset the circuit breakers and this could be a repetitive problem.

5. How to ensure a perfect installation

Here are a few tips for ensuring that EverLink is installed correctly and to avoid poor connections during product life:

Figure 10
Installation



- Use a cable that is adapted to the connection (section, material, cable type, etc…)
- Prepare the cable accordingly, (twisting of cables, clamps, for example) and insulate the cable to the required length.
- Unscrew the connection entirely if necessary.
- Insert cable and tighten using the recommended tools. Be aware that tightening an Everlink connection may provide a different feel due to spring effect of the lug.
- Do not overtighten, and do respect torque, as recommended by using a torque wrench and torque breakaway bits.
- Ensure cables are securely tightened in connection by gently pulling on them.
- Check the installation on an annual basis, using thermal screening. In the event that thermal screening is not available, carry out an additional re-tightening.

6. Conclusion

Safety and reliability are the two principal considerations for electrical installation power connections. If these factors are not given sufficient attention, installations may be at risk of electrical fires and other electrical-related damage.

Schneider Electric EverLink technology is designed to offer customers peace of mind in terms of reliability, maintenance and continuity of service. Because EverLink requires no regular re-tightening of its power connections, maintenance is thus optimized.

Furthermore, in the past, customers have sometimes suffered from installations in which overheating of connectors has caused inadvertent circuit breaker tripping. Likewise, customers have for a long time faced the risk of overheating - which can lead to serious damage to circuit breakers and/or associated wires.

Thanks to its patented spring effect technology, EverLink mitigates the effect of creeping, ensuring that power connection cables are kept tight, to ensure customers have a reliable, long-lasting connection within their electrical installations.

About the authors

Daniel Vanzetto is a senior inventor at Schneider Electric's R&D center. He has strong experience as a terminal specialist and works at a global level on many new connecting solutions with major patents. He also works very closely with suppliers for launching new and interesting technologies, or to optimize existing designs. Daniel is one of Schneider Electric's foremost authorities on connections.

Emir Boumediene is a manager of Simulation & Mechanisms in the Schneider Electric Architecture & Innovation group within the Building and IT department. He holds an MSc in Mechanics and an MSc in Biomechanics from the Arts et Métiers ParisTech Engineering School. He has worked on several topics related to mechanics and connection within the group.

Resources

Using Infrared (IR) Thermography
to Improve Electrical Preventive Maintenance Programs
White Paper

Strategies for Maintaining Electrical Distribution Equipment
White Paper

Browse all white papers
download.schneider-electric.com

MyPact Tool
Online selector to configure LV circuit breakers

Contact us

If you are a customer and have questions specific to your project:

Contact your Schneider Electric representative at
https://www.schneider-electric.com/en/work/support/