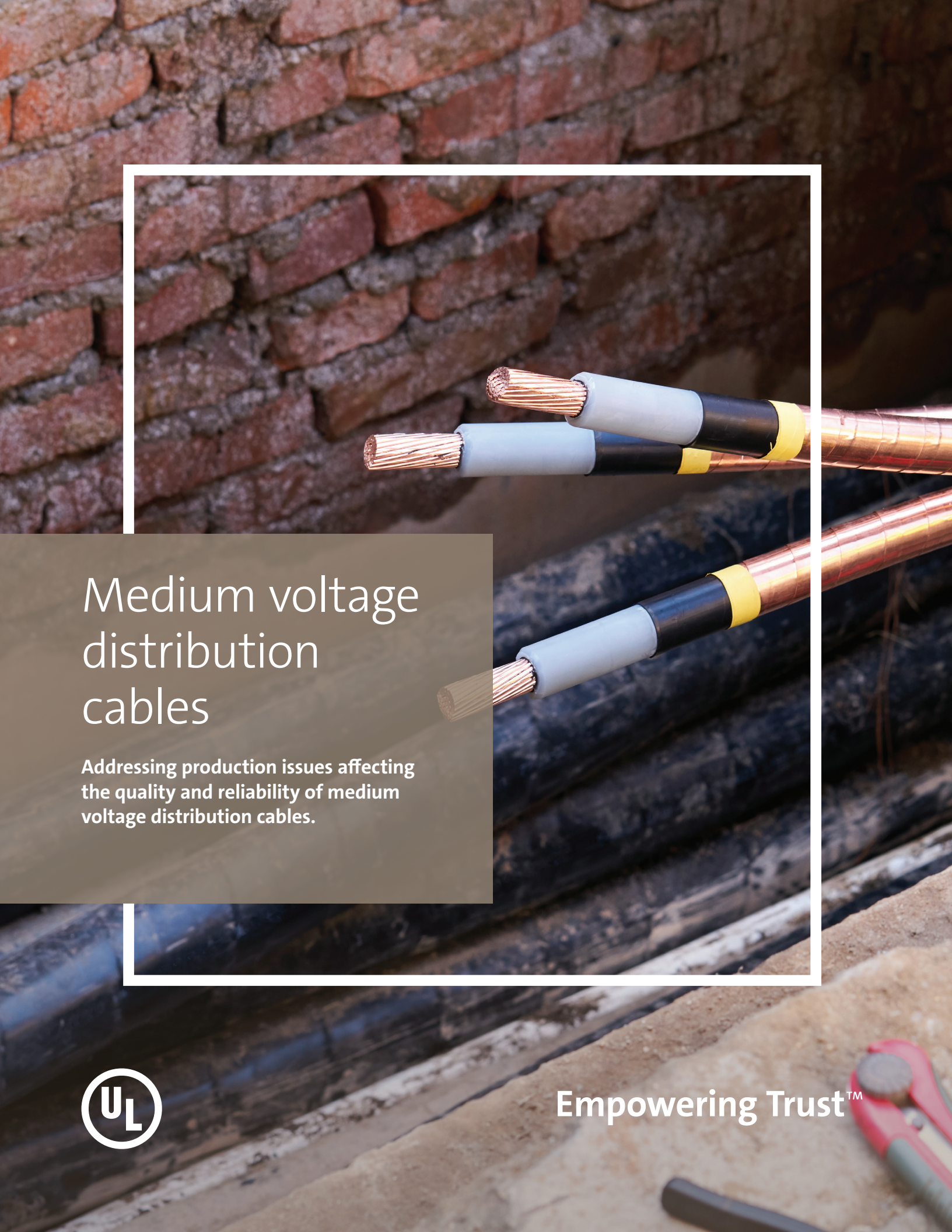


Medium voltage distribution cables

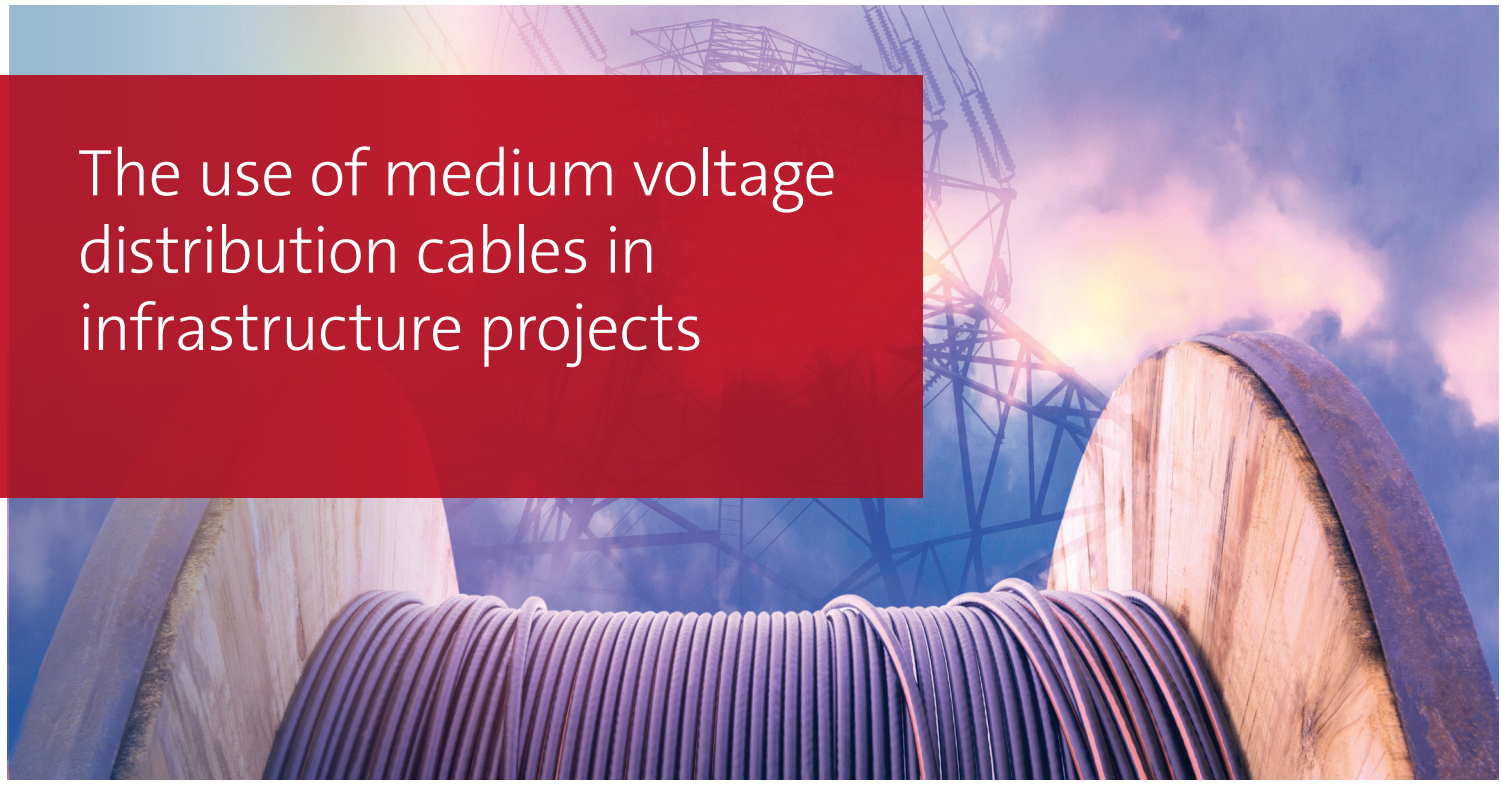
Addressing production issues affecting the quality and reliability of medium voltage distribution cables.

Empowering Trust™

Executive Summary

The quality of medium voltage distribution cables is a critical factor in efforts to help ensure the safe and reliable routing and distribution of electrical power used in utilities and other industrial environments. Yet, a variety of factors related to cable production can compromise cable quality, potentially shortening the anticipated life of essential cable installations and resulting in costly repairs and service downtime.

This UL white paper discusses the factors related to the premature failure of medium voltage distribution cables, including those involving production practices and procedures. The paper also outlines the steps that utilities and other industrial users of medium voltage distribution cables can take to monitor cable quality throughout the procurement process, thereby helping to reduce incidents of preventable cable failure. The white paper concludes by reviewing UL's audit and inspection programs for medium voltage distribution cables.



The use of medium voltage distribution cables in infrastructure projects

Medium voltage distribution cables and components are quickly becoming an essential element in the effort to maintain and expand the capabilities of the global energy infrastructure. Operating in voltages ranging from 2,000 to 46,000 volts, medium voltage cables are already being used in a wide range of industrial applications, including energy utilities, oil and gas exploration, mining and metals, and manufacturing. And future investments in power transmission and distribution systems are expected to drive increased demand for medium voltage cables and accessories in the years ahead.[1]

At the same time, the growing reliance on the use of medium voltage distribution cables presents a number of challenges related to premature cable failure in the field. The expected life of an underground, insulated distribution cable varies widely, but typically averages about 30 years. But a wide range of issues, such as average power load, installation conditions and exposure to extreme weather for both underground and overhead cables, can significantly reduce the average expected life of installed cables.

Regardless of the cause, premature cable failure is one of several factors contributing to significant increases in spending on maintenance by utility companies. The U.S. Energy Information Agency (EIA) reports that spending by the U.S. utility industry on operations and maintenance now exceeds $13 billion annually, an increase of nearly 400 percent in 20 years.[2] But cable failures lead to more than just costly and time-consuming repairs or replacement operations for utility companies, or temporary inconvenience for utility customers. When they result in partial or widespread power outages, premature cable failures can impose a significant economic cost on the affected communities, and even put lives at risk.

For these reasons, the quality and reliability of medium voltage distribution cables has become a critical consideration in cable procurement practices in the utility industry as well as among other industrial users. As part of that effort, cable manufacturers are increasingly being asked to provide assurances to their customers not just about whether their products meet applicable safety and performance standards, but whether their manufacturing systems and quality assurance processes are sufficient to help ensure the continuous production of cable products that meet their exacting specifications.

Some causes behind medium voltage distribution cable failures

Premature in-service failures of medium voltage distribution cables can be attributed to a number of various causes. In general, these causes fall into one of the following categories:

Issues related to cable design and construction

Medium voltage distribution cables currently available on the market incorporate significant technical advances that generally serve to improve the safety, quality and efficiency of power distribution. At the same time, today's medium voltage cables represent complex constructions of various materials and components. In some cases, type testing of unique designs and material combinations may not be sufficient to identify potential quality deficiencies that can eventually lead to premature cable failure, ultimately leaving it to the cable purchaser to verify compliance with required specifications.

Application-related problems

Applications for medium voltage distribution cables vary considerably in terms of the technical specifications that must be met to ensure optimal operating performance in actual use. However, product selection and procurement protocols that are not sufficiently rigorous can lead to the selection of medium voltage cable products that are underrated or otherwise incompatible with the intended application. In such cases, installed cables may be subjected to operating conditions outside of their specified parameters, leading to electrical overloading and premature failure.

In-use conditions

While some environmental factors can be difficult to predict, such as tornadoes and other extreme weather events, most medium voltage distribution cable exposure risks, including excessive heat, cold and moisture, fall within relatively predictable parameters. Similarly, medium voltage cables that are accessible to rodents, birds and other wildlife are likely to experience higher rates of damage to cable sheathing and insulation, exposing sensitive internal cable components to the elements. Unfortunately, reasonably anticipated, in-use conditions are often given inadequate consideration during the cable specification process.

In many cases, reducing the risk of premature cable failures attributable to these causes can be addressed by implementing stronger process and procedural controls in the specification and procurement of cable products. However, even the most robust specification and procurement protocols may not be sufficient to identify variations and anomalies in a cable supplier's manufacturing and production processes that result in cable product of inconsistent quality or reliability.

Production factors affecting the reliability of medium voltage distribution cables

Cables, and medium voltage distribution cables in particular, are unique among most of the equipment, products and materials used in the utility infrastructure and in other power-related industrial operations. Rather than being assembled from a number of separate components, cables are extruded in a continuous flow manufacturing process that seamlessly integrates the essential conductor, shielding and insulation elements into a finished cable system. In theory, this approach enables manufacturers to efficiently produce thousands of linear feet of quality, finished cable to the required specifications.

The problem is that the quality of the output from a continuous flow manufacturing process requires constant monitoring and correction of process variables, such as production line speed and pressure, as well as production-related environmental factors like temperature, humidity and airborne contaminants. If not tightly controlled, deviations in any of these variables can increase the risk of product defects in finished cable products, defects that may go undetected during normal production testing and product commissioning.

These potential problems may be additionally compounded by production workers who are insufficiently experienced or improperly trained in cable production. Seemingly minor human errors, such as pulling extruded cable along a rough floor surface, failing to pay attention to minor variations in process reel take-ups, or accidentally inflicting minor nicks in the cable surface can occur without notice, resulting in undetected flaws or defects.

Further, inadequate or outdated testing facilities and equipment and technicians who lack sufficient understanding of testing procedures can miss obvious cable defects and even introduce new ones during the testing process. In some cases, problems with faulty testing equipment go unrecognized and remain unaddressed. Other issues can be attributed to the partial discharge testing phase, where cables are not sufficiently degassed prior to testing or technicians lack the proper training to correctly perform partial discharge measurements and calibration.

The unfortunate result of these production-related shortcomings is the increased potential for the commissioning of medium voltage distribution cable that contains flaws and defects. These defects may go unnoticed for years before leading to a cable fault or failure well before the end of the cable product's expected service life but long after the end of any applicable warranty period. This then requires the repair or replacement of the defective cable ahead of any planned infrastructure upgrade schedule, with the cost borne entirely by the user.

Other issues

Lastly, there are several issues not related to design or production that can impact the quality and long-term reliability performance of medium voltage distribution cables.

For example, in the area of standards, technical standards applicable in North American markets typically include some requirements intended to identify or address cable product defects prior to shipment. Testing under these standards can impose longer wait times between core extrusion processes and partial discharge testing, or account for quality variables attributable to the length of production runs, etc. But requirements of comparable international standards may differ in significant ways, ultimately leaving it to the buyer to determine whether the requirements of a given standard or standards satisfactorily addresses their specific quality and reliability concerns.

Another issue has to do with the challenges presented by the prevalence of global supply chains. Increasingly, medium voltage distribution cable is sourced from cable producers with manufacturing operations and subcontractors located around the world. Although global supply chains offer a number of benefits to manufacturers and buyers alike, manufacturing performance standards can vary widely from one operation to another, creating the potential for significant variations in the quality and reliability of what is ostensibly the same cable product. Rigorous supplier quality control programs and audit protocols can help to address this problem, but such programs can be costly and time-consuming to implement and manage, especially for smaller cable producers.

The problem is further magnified by the decrease in the use of utility-run inspection programs at cable production facilities due to their added cost.

A final issue reflects the reduced availability of requisite technical knowledge and expertise related to cable technology in general. The energy industry is facing a critical skills gap, with the number of new workers entering the industry falling short of those older, more experienced workers who are leaving the workforce.[3] As a result, fewer utility industry professionals possess the requisite technical knowledge regarding proper cable construction, testing, installation and maintenance. In the end, this gap is likely to increase the likelihood that substandard or defective medium voltage distribution cable will find its way to the market and be integrated into critical operations.

Ensuring the quality and reliability of medium voltage distribution cables

In this context, the effort to address these and other issues related to the quality and reliability of medium voltage distribution cables presents a critical challenge to the utility industry and other industrial users. At the same time, there are several actions that buyers of medium voltage cables can take to help ensure the overall quality of their purchases, and to reduce the incidence of premature cable failures.

These actions include:

Vendor qualification assessments

Procurement organizations can implement rigorous vendor quality assessment programs to help ensure that cable manufacturers and producers are sufficiently qualified to consistently deliver products that meet regulatory and industry requirements, as well as the specifications of their intended application. Such a program should include both assessments to initially qualify a vendor as a potential source for cable products, as well as a provision for periodic reevaluation and requalification.

Ongoing product inspection and testing

Procured cable product should be subject to routine inspection and testing of random product samples to help ensure conformity with contracted cable specifications. In-house quality management teams should track and document inspection and testing results to proactively identify potential problems with specific suppliers or production facilities. Continued instances of supplying cable product that fails to meet procurement requirements or is damaged or defective in any way should be grounds for termination or increased oversight of a supplier's procurement agreement with that company.

Adequate supply chain oversight

To help ensure the quality of cable product from supply chain partners, buyers should require cable manufacturers and producers to provide evidence of quality management oversight of supply chain activities. These activities could include site certification of partner production facilities in accordance with relevant quality management standards, inspection and testing of randomly-selected cable product samples, and periodic factory audits.

Workforce training

Addressing the technical information gap among workers in industry today is a challenge that requires an ongoing commitment to provide sufficient training and education opportunities. The investment to initiate and deliver such training will be offset by a higher level of workforce knowledge and expertise, resulting in the more efficient identification of potentially defective cables and a reduction in the deployment of cable likely to fail prematurely. Investments in workforce training can also have the added benefit of increasing overall employee engagement and productivity.

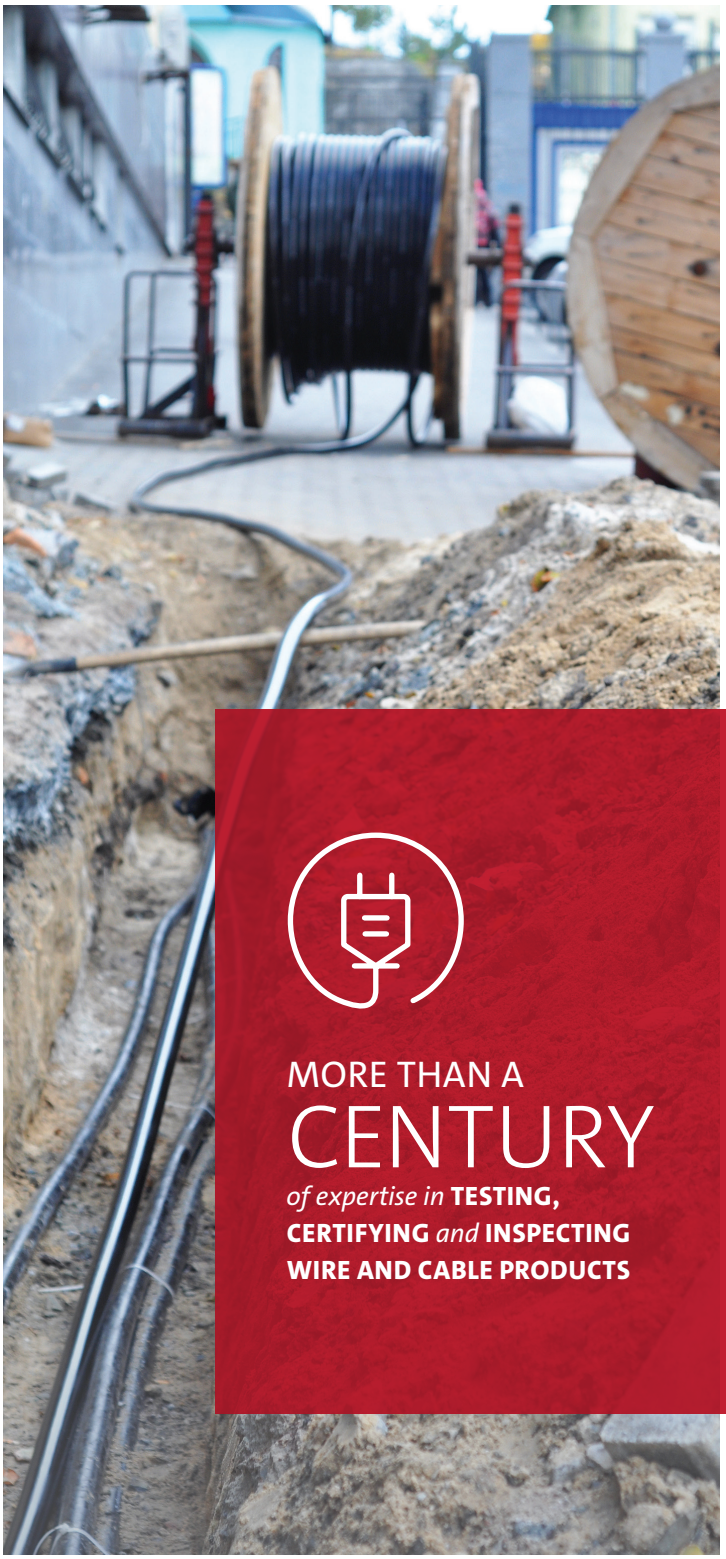
By taking these actions, utility companies and other industrial users of medium voltage distribution cable can help to reduce the incidence of premature cable failures and the need for unplanned repairs and maintenance of installed cable.

UL's approach to medium voltage quality and reliability

Leveraging more than a century of expertise in testing, certifying and inspecting wire and cable products, UL's Wire and Cable division has developed two specialized programs to provide utilities and other industrial cable customers with assurances regarding the quality and reliability of their cable purchases. Our Medium Voltage Cable Supplier Qualification Audit and Inspection programs focus on cable manufacturing standards and techniques that are unique to medium voltage distribution cables, while also addressing vendor testing capabilities, equipment and methods, quality systems and employee training. And our global network of specialized auditors and inspectors facilitate the monitoring and evaluation of supply chain facilities, regardless of their location.

Under these programs, we work directly with cable customers to specify UL audits and inspection services as mandatory provisions in procurement contracts and agreements with cable manufacturers and providers. This approach effectively shifts the responsibility to the cable manufacturer to meet rigorous quality and performance requirements for commissioned cable, while being cost-neutral to the cable customer. Other benefits of UL's Medium Voltage Cable Supplier Qualification Audit and Inspection programs include:

- Greater assurances regarding vendor compliance with stated quality and reliability specifications for cable purchases;
- Reduced time spent on direct oversight of cable suppliers, including supplier audits and inspections;
- Increased focus on core competencies, including product design, specification and selection; and
- Less spending related to audits of cable supplier production facilities, including travel time and expenses, translators, etc.



Summary + Conclusion

The quality and reliability of medium voltage distribution cable is of vital interest to the utility industry and other industrial entities, since defective cable products can result in premature cable failure and potentially significant consequences. Yet, producing high-quality medium voltage cable that meets buyers' exacting specifications is fraught with challenges, a problem amplified by the declining availability of production personnel with the requisite technical knowledge and expertise. Therefore, cable purchasers must be prepared to fill this void with more rigorous procurement practices and increased attention to the quality of commissioned cable products.

UL's Medium Voltage Cable Supplier Qualification Audit and Inspection programs can provide specifiers and purchasers with assurances regarding the quality and reliability of products obtained from cable manufacturers and producers, reducing the potential for premature cable failure, as well as the risks associated with such failures. Our audit and inspection programs for medium voltage distribution cables can also free up important buyer resources, while giving utility companies more flexibility in meeting the demands for reliable energy in the 21st century.

For more information about UL's qualification programs for medium voltage distribution cables, or about UL's other wire and cable testing, certification and inspection services, visit UL.com/wireandcable

End Notes

1. "Medium Voltage Cables and Accessories Market Worth $56.18 Billion USD by 2022," a report by Markets and Markets, September 2017. Web. 16 April 2017. https://www.marketsandmarkets.com/Market-Reports/medium-voltage-cable-market-15193142.html.

2. Based on data from the U.S. Energy Information Administration, as reported in "Utilities Continue to Increase Spending on Transmission Infrastructure," a posting on the website of the energy collective, January 16, 2018. Web. 16 April 2018. http://www.theenergycollective.com/todayinenergy/2423726/utilities-continue-increase-spending-transmission-infrastructure.

3. "Building an Energy Workforce for the 21st Century," a report prepared by the Democratic Staff of the U.S. Senate Committee on Energy & Natural Resources," August 2016. Web. 16 April 2018. https://www.energy.senate.gov/public/index.cfm/files/serve?File_id=4269D9FB-3713-4371-AD66-CE9117A54E5D.