POWERING AND CHARGING SAFETY FOR DATA SYNC AND CHARGER CABLES

EXECUTIVE SUMMARY

First introduced in the 1990s, cables and connectors based on universal serial bus (USB) technology have made possible today's nearly seamless interoperability between information and communication technology (ICT) devices from diverse manufacturers and suppliers. USB technology has largely replaced the once ubiquitous serial and parallel port connections that served as the primary means of connecting peripheral devices to computers, and has facilitated the connection of a whole host of more advanced ICT devices, including smart phones, portable media players, disk drives and network adaptors. Although the USB interface was designed from the outset to provide at least some power to connected devices, the current generation of USB technologies utilizing a new generation of connectors allows users to supply and transfer higher electric power between devices than ever before.

As USB-powering technology has evolved, the widespread adoption and use of the various USB connectors - including their use for some non-USB applications - has presented its own set of challenges. Although power delivery and battery charging protocols are carefully and fully defined in the various USB specifications, non-compliant devices and cables have resulted in problems encountered by users. These problems include slow charging rates, devices which fail to function as intended, and damage that could lead to the increased risk of fire. In at least two reported instances, substandard cables contributed to an excessive surge in electrical power that resulted in the destruction of connected laptop computers.

This UL white paper discusses the causes and consequences of the safety issues related to powered connectivity, and presents a brief summary of the results of recent safety testing conducted by UL on ICT power and charging cables and connectors. The paper then reviews the assessment methodology behind UL 9990, Outline of Investigation for Information and Communication Technology (ICT) Power Cables, as well as UL's ICT power cable safety certification program. The white paper concludes with a discussion of how UL safety-certified data sync, power and charging cables can reduce the risk of damage to ICT devices due to compatibility issues and mitigate fire propagation concerns.

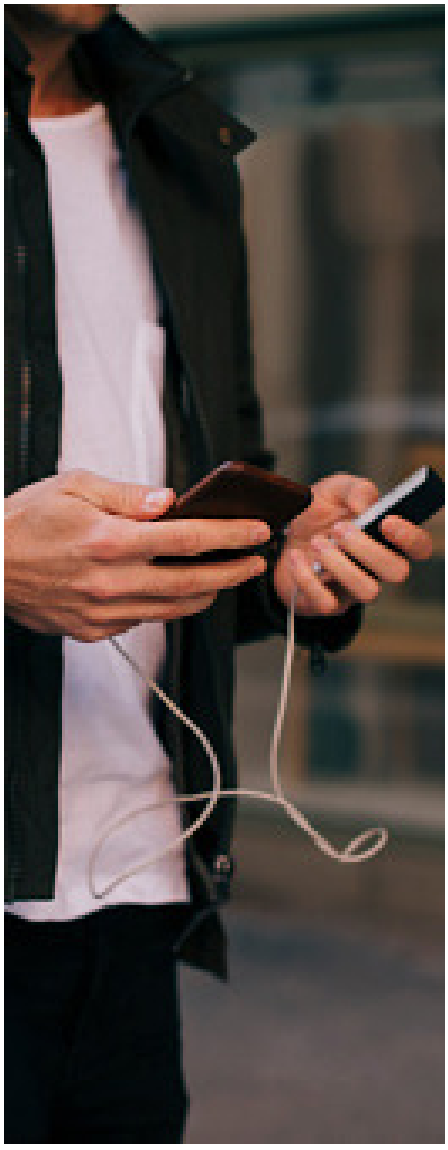
THE EVOLUTION OF USB TECHNOLOGY

For more than 20 years, the continued development of USB technologies has made an essential contribution to the introduction of advanced ICT devices. During that period, USB protocols have been updated or revised from time to time offering improvements in data transfer speeds and cross-platform compatibility. These advancements have helped drive the overall performance of computers, laptops, tablets and smartphones, and have greatly simplified connectivity issues for billions of technology users worldwide.

To give just one example of this dramatic progress, the original USB 1.0 specification provided maximum data transfer rates of 1.5 megabytes per second. Cables, connectors and receptacles based on USB 3.0 series specifications support data transfer rates starting at 5 gigabits per second. And the latest USB specification, USB 3.2, is expected to support data transfer rates approaching 20 gigabits per second, nearly 1000 times faster than USB connectors based on the original USB 1.0 protocol.

With the concurrent development of USB power delivery specifications developed by USB Implementers Forum (USB-IF), cables based on USB 3.0 series specifications provide a more substantial direct power connection between connected devices. Issued in early 2017, USB Power Delivery revision 3.0 provides for a maximum power of up to 20 volts at 5 amps utilizing a new, specially designed miniature connector, compared with just 5 volts at 1.5 amps in the earliest battery charging specification and only 0.5 amperes in the USB 2.0 specification. This capability effectively enables devices to be powered through connections to other powered devices, and helps to reduce the need for dedicated power connections in every device.

Lastly, USB devices designed to the USB 3.0 series protocols support the use of backward compatible cables and connectors. When designed in accordance with the USB specification, USB 3.0 cables and connectors feature a small, reversible-plug connector that connects to both host computers and devices. Compatible receptacles have been widely adopted by most manufacturers, and have gradually become standard on many models of laptop computers, tablets and smart phones.



THE USB IMPLEMENTERS FORUM

The rapid development and widespread deployment of advanced USB technologies is due in no small part to the collaborative effort by the ICT industry to develop and maintain common technical specifications. Formed in the early 1990s by a small group of leading technology companies, USB-IF is a non-profit group that supports the broad acceptance of USB technologies through the development of industry-accepted specifications. Now with more than 700 member companies, the work of the USB-IF has been instrumental in helping ICT developers move away from the myriad of incompatible ports and connectors and to adopt common, interchangeable connection technology.

USB-IF has developed a number of technical specifications that address design and performance aspects for various USB technologies in multiple connector applications. However, the primary USB-IF specifications fall into one of the following categories:

- **USB TECHNOLOGY SPECIFICATIONS -** USB technology specifications define data transfer rates for USB devices. USB 1.0 was the first specification issued by the USB-IF and was published in 1996. The current USB technology specification, USB 3.2, was published in September 2017.
- **CONNECTOR SPECIFICATIONS -** USB-IF connector specifications define connector properties, including size, orientation, receptacle/plug characteristics, durability and compatibility. The most recent USB-IF connector specification was published in late 2014.
- **POWER DELIVERY SPECIFICATIONS -** USB-IF power delivery specifications were developed to support the delivery of increased power through USB connectors and cables. The current power delivery standard is USB Power Delivery revision 3.0 (version 1.1), which was published in early 2017.

To help ensure USB device compatibility with these and other specifications, the USB-IF has also created a compliance program to assess newly-developed USB connectors, cable assemblies and other devices. Under this program, USB devices are subject to specified testing consistent with the device type. Testing is conducted by USB-IF authorized third-party testing laboratories, or device manufacturers can opt to participate in USB-IF sponsored compliance workshops. USB devices which pass these product tests are added to the USB-IF's Integrators List of approved products, and manufacturers of approved products are eligible to license and use the USB-IF logo in the marketing of their products.[1]

USB devices that display legitimately obtained USB-IF logos can help provide retailers and consumers with assurances regarding the performance of those devices. Unfortunately, in some cases, USB products with counterfeit logos have been identified that may or may not have undergone USB-IF testing.[2] In addition, it is important to note that testing under the USB-IF certification program is not a substitute for the product safety requirements and certification applicable to connectors and cable assemblies. This safety evaluation must be conducted separately and in accordance with applicable regulations and technical standards.

IN SEPARATE TESTING RECENTLY CONDUCTED BY UL, A RANDOM SET OF NON-CERTIFIED USB CABLES PURCHASED ON THE OPEN MARKET WERE SUBJECTED TO CABLE FLAME TESTS IN ACCORDANCE WITH UL SAFETY STANDARDS. ALTHOUGH THE SAMPLE SIZE WAS RELATIVELY SMALL, LESS THAN 28-PERCENT OF THE CABLES TESTED PASSED THE FLAME TEST AND MANY OF THE TESTED SAMPLES WERE COMPLETELY CONSUMED BY FIRE.

THE CHALLENGES WITH POWER CABLES AND ADAPTORS

The introduction of new connection specifications have contributed to significant advancements in the design and portability of ICT devices. Because of smaller profiles, these receptacles and ports have helped designers create ICT devices with thinner profiles and less weight. And, because most of the new connections should be backward compatible, users can more easily connect devices and peripherals based on earlier USB specifications, including USB 1.0 and USB 2.0.

Devices that incorporate technology consistent with the latest USB specification for power delivery have also eliminated the need for dedicated power ports, giving users greater flexibility for charging their devices. However, this potential advantage can be offset by poorly constructed ICT power cables and adaptors. In some cases, the connectors on these devices simply fail to meet the correct connector specifications. In other instances, the cable/adaptor assembly is not appropriately designed to safely carry the required electrical current, required electronic markers intended to identify power requirements or capabilities do not function as intended, or the wiring is not properly terminated. And some cables and adaptors are constructed from materials that have insufficient thermal and flame resistance properties, creating the potential for overheating or the risk of fire spread.

Unfortunately, such defects in ICT power cables can actually disable or destroy the devices to which they are connected. In a widely circulated report posted to the CNET website in early 2016, two technology professionals reported that their laptop computers were severely damaged when they plugged in USB-C-to-USB-A adaptors that had been purchased online. In both cases, the problem was linked to a resistor used in the adaptors that did not meet applicable USB-IF specifications.[3] One of the two professionals involved, an engineer at Google, subsequently evaluated over 100 different adapters available on line, and determined that more than half of them failed to meet the applicable USB specifications.

In separate testing recently conducted by UL, a random set of non-certified USB cables purchased on the open market were subjected to cable flame tests in accordance with UL safety standards. Although the sample size was relatively small, less than 28-percent of the cables tested passed the flame test, and many of the tested samples were completely consumed by fire.

While poor construction is a key factor in defective cables and adaptors, the variety of configurations and general lack of knowledge about the meaning of cable logos and markings can also contribute to confusion among consumers. This confusion can result in the purchase of ICT power cables that meet applicable specifications but that are incompatible with their actual devices. These logos and markings are often not visible in online listings of cable products available for purchase, requiring consumers to rely on vague or unclear descriptions to assess a given cable or adaptor's suitability for their devices.

ICT POWER CABLES AND UL 9990

As part of the effort to address potential concerns regarding the safe operation of ICT cables used to provide power to low-powered electronic devices, UL has prepared UL 9990, Outline of Investigation for Information and Communications Technology (ICT) Power Cables. The criteria in UL 9990 have been developed to complement USB performance specifications, and together they provide a basis for the comprehensive evaluation of both the performance and safety characteristics of USB cables.

UL 9990 ADDRESSES THE FOLLOWING KEY ASPECTS OF ICT POWER CABLE DESIGN, SAFETY AND PERFORMANCE:

CONSTRUCTION

Cables and any provided decorative coverings are required to be flame-rated minimum VW-1, or pass an equivalent flame test to limit the spread of flame should a fire start in either the power source or the powered device. The connectors must be constructed of materials that meet a minimum flame rating of V-1, or that comply with the applicable small scale flame tests. In addition, ratings must comply with the applicable maximum limit as detailed in the relevant specification for that cable or cable assembly, and electronic markers in the cable must be consistent with the ratings and the relevant USB powering technologies.

SAFETY PERFORMANCE

Under UL 9990, cable assemblies are subject to the following sequence of tests:

- **STRAIN-RELIEF TEST**
  The strain-relief test verifies that a cable assembly, components and wiring remain intact under tension.
- **FLEXING TEST**
  Cable assemblies are subject to a specified number of flexing cycles. Breakage of the conductor or insulation under flexing results in a test failure.
- **NORMAL TEMPERATURE TEST**
  Under operating conditions, cable temperature cannot rise to more than 30°C (54°F) above ambient temperature.
- **DIELECTRIC VOLTAGE-WITHSTAND TEST**
  Following the above tests, cable assemblies are subjected to a 500 volt DC charge for a period of one minute, and must not experience arc-over or breakdown.
- **FAULT CURRENT TEST**
  Finally, a cable assembly is draped with a piece of cheesecloth and a DC test current of 8 amps (the upper limit for power limited circuits) is applied for a minimum duration of 30 minutes. The cable assembly under test shall not ignite, or emit a flame or molten metal, and the draped cheesecloth shall not char.

MANUFACTURING AND PRODUCTION

During the actual manufacturing and production of cable assemblies, each unit is tested to ensure correct electrical continuity throughout the entire length of the conductor/contact assembly.

MARKINGS

UL 9990 includes detailed specific marking requirements for product packaging that identify the length of the cable and the maximum voltage and current ratings tested, as well as other information intended to help identify the manufacturer and the specific factory where the cable or cable assembly was produced.

It is important to note that the scope of cable assemblies evaluated in accordance with the specifications in UL 9990 is limited to those with not more than one connector at each end. This is because cable assemblies with multiple connectors pose of risk of back-powering ports with powering voltages. In addition, so-called “cheater” cables, that is, cables that are designed to place connected devices into unintended modes of operation, or disable or interfere with intended system operation, are also excluded from the scope of UL 9990. Finally, the signal transmission performance of the cable or cable assembly under test is not evaluated.

UL'S ICT POWER CABLE SAFETY CERTIFICATION PROGRAM

UL has integrated UL 9990 into a comprehensive safety certification program for ICT power and charging cable assemblies. The certification program includes an evaluation of the design and safety of ICT power cables in accordance with the technical requirements of UL 9990. In addition, UL conducts post-certification inspection and testing of factory production units as well as product samples purchased on the open market to help ensure ongoing compliance with the applicable safety requirements.

For USB cable assemblies that have not been previously reviewed and approved in accordance with relevant USB specifications, UL is also equipped to conduct USB performance testing at UL facilities that have been approved by the USB-IF as authorized independent testing laboratories. This enables cable manufacturers and distributors to work with a single testing entity that can conduct testing as required by regulatory authorities and the USB-IF, as well as additional product safety testing under UL's ICT power cable safety certification program.

THE BENEFITS OF UL'S POWER CABLE SAFETY CERTIFICATION PROGRAM

UL's safety certification program for ICT power and charging cables and adaptors offers manufacturers and distributors a number of important benefits, as follows:

- **COMPREHENSIVE, SINGLE-SOURCE, THIRD-PARTY TESTING**
  UL can serve as a single source for the complete range of safety testing as required by national regulators as well as performance testing in accordance with industry-accepted specifications, thereby helping to facilitate regulatory approval and market acceptance.

- **INCORPORATED COMPATIBILITY AND SAFETY CONSIDERATIONS**
  Because it can combine product safety testing and testing to USB-IF performance specifications, certification under UL's power cable safety certification program provides retailers and buyers with assurances regarding both the quality and safety of certified power cables and adapters.

- **ONGOING ASSESSMENT OF COMPLIANCE THROUGH UL'S FOLLOW-UP INSPECTION AND TESTING**
  UL's post-certification inspection and testing of production units helps to ensure continued compliance with applicable requirements, and can serve as an essential aspect of supply chain management efforts.

- **ENHANCED SECURITY AND INTEGRITY OF SAFETY CERTIFICATION MARKS**
  UL's intensive anti-counterfeiting efforts help to reduce the use of unauthorized certification markings on untested products, preserving the value of legitimate ICT power cables and adaptors.

- **GLOBALLY RECOGNIZED CERTIFICATION**
  Finally, the UL Mark is recognized by brand owners, distributors, major retailers and consumers throughout the world.

SUMMARY + CONCLUSION

Advances in USB technology have made important contributions to the ongoing innovation in ICT products and devices. At the same time, inexpensive or poorly designed power and charging cables and connectors pose a potential safety risk to users, and have even resulted in damage to or the destruction of some connected ICT devices. Complementing existing industry specifications regarding USB performance, UL's power cable certification program provides a comprehensive assessment of the safety of ICT power and charging cables, and can provide buyers with assurance regarding both their quality and safety.

For more information about ICT power cable testing and UL's ICT power cable safety certification program, please contact: **ROBERT.S.LAROCCA@UL.COM** or visit **UL.COM/CHARGINGCABLE**

END NOTES

1. See: www.usb.org/kcompliance/view.
2. For example, see “How to Buy USB Type-C Cables That Won’t Fry Your Gadgets,” Feb. 7 2016. www.laptopmag.com/articles/how-to-find-safe-usb-type-c-cables.
3. “Should you fear your USB cable?” Feb 28 2016. www.cnet.com/news/usb-type-c-cable-problems/.

+1 847 272 8800 • UL.com