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Selecting Power Connectors that can Deliver Consistently **Reliable Performance** in Demanding Environments

By Jeff Shepard

Transportation systems, industrial equipment, signage, commercial and industrial lighting, and electric vehicles are among the applications needing power connectors that can deliver consistently reliable performance in demanding environments.

The connectors in those applications need to be sealed against the elements and meet IP68 and IP69K standards, have locking mechanisms and shock and vibration ratings to resist even momentary disconnection, have housings made with a high thermoplastic polyester material like polybutylene terephthalate (PBT) that's resistant to ultraviolet (UV) light, chemicals and high temperatures, and they must meet an array of safety and performance regulations.

"In order to meet the needs of today's higher-current applications, we wanted to develop a whole new connector that specifically addressed those needs," says Dan Sima, Marketing Director for Switchcraft, Inc. "We had a lot of customers who wanted our connectors to handle more power, but when we looked at modifying existing connectors with bigger contacts, we felt they weren't suitable beyond a certain level. The EP7 Series was designed with all of its features equipped for higher-power applications."

These connectors must be rated for 600 V AC and DC and 30 A and available in 3-pole, 4-pole and 5-pole configurations designed to withstand a minimum of 400 insertion/withdrawal cycles to support a variety of system implementations.

This article presents the Switchcraft EP7 series power connectors and reviews how their rugged design meets the performance requirements for use in demanding environments (Figure 1). It looks at how the 3-pole, 4-pole and 5-pole configurations support electrical flexibility for different wiring topologies and how the three cable configurations and mating cycle life provide mechanical flexibility that can support designers' needs for a single family of connectors that can be used in a range of system designs.



Figure 1: Switchcraft EP7 series power connectors are designed to deliver consistently reliable performance in harsh environments. (Image: Switchcraft)

ENVIRONMENTAL PERFORMANCE STANDARDS

Specifying environmentally rugged connectors starts with ingress protection (IP) ratings and compliance with UL 746C. A high IP rating is required for applications like outdoor lighting and industrial systems, anywhere that's potentially exposed to high levels of dust, dirt and moisture. A higher IP rating means the connector can handle harsher conditions without malfunctioning or posing a safety risk.

"Switchcraft's main focus and expertise is products made for harsh environments," Sima says. "Switchcraft products are made in the USA using premium quality materials. We were able to apply that expertise and standard of quality to the development of this product series."

The IP rating scale is defined by the International Electrotechnical Commission (IEC) standard 60529. It consists of two numbers. The first digit indicates the level of protection against solid particles. The highest performance is indicated with a "6" for complete protection from dust. The second digit indicates the level of protection against water. The highest performance is indicated with an "9" for complete protection powerful high-temperature water jets.

Connectors with an IP69 rating provide a high degree of protection from dust and water. Even more protection is provided by a connector with an IP69K rating for high-pressure, high-temperature wash-down applications. IP69K is an extension of the IP rating system defined in International Organization for Standardization (ISO) standard 20653. The EP7 series meets both IP69 and IP69K requirements.

For outdoor or industrial applications that need protection from driving rain and water, but not powerful water jets, an IP68 rating is usually sufficient. It indicates complete protection from dust and protection from submersion in water 1 meter deep. EP7 series power connectors meet the requirements of IP66, IP67, IP68 and IP69K making them suitable for use in a wide range of challenging environments.

Once the needed IP rating has been specified, it's necessary to look for a connector made with the right

materials. That's where UL746C comes in. It sets standards for polymeric materials used in electrical equipment, like connector housings.

RUGGED MATERIALS

A material with a UL F1 rating is suitable for use outdoors. It meets the testing requirements of UL746C including exposure to UV rays, moisture and underwater conditions. The testing includes exposure to UV light for up to 1,000 hours (depending on the light source and the exact wavelength of UV being used) and immersed in water at 70 °C for 7 days.

The mechanical properties and flammability of the material are compared before and after testing. If it retains its mechanical properties and flammability capability, it's rated F1. Materials with a rating of F2 have passed either the UV or water immersion testing or may have been only partially tested. Connectors for outdoor or industrial applications should have housing materials rated UL F1 like the EP7 series.

The outer shell of EP7 power connectors is a high-quality PBT that has high strength, rigidity, and toughness. Other desirable traits of PBT include:

- High dimensional stability.
- Resistant to a wide range of chemicals, solvents, oils and greases.
- High dielectric strength and good insulation properties.
- High impact strength, even at low temperatures.

The seal gromets are made with thermoplastic vulcanizates (TPVs). Desirable properties of TPVs include:

- Chemical resistance.
- Good aging properties and good long-term performance.
- Good resistance to compression setting.
- Wide operating temperature range.
- Resistance to flex fatigue.
- Good recovery from elastic deformation.

The seal O-rings are made with VMQ silicone rubber. VMQ is flexible at low temperatures and has high air and gas impermeability even at extreme temperatures. The combination of a rugged design and high-quality materials enables EP7 power connectors to have a rated temperature range of -40 to +135 °C.

ELECTRICAL VERSATILITY

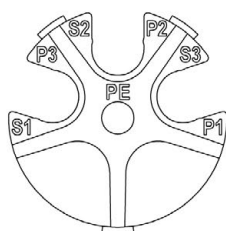
Of course, environmental ruggedness is necessary to ensure reliable operation in lighting and industrial systems, but electrical connectivity is the primary purpose of connectors. The EP7 series provides a high degree of electrical performance and versatility.

The EP7 series is rated for 600 V AC or DC per UL 2238, the standard for Cable Assemblies and Fittings for Industrial Control and Signal Distribution, and up to 30 A. Power connectors must efficiently deliver high currents and voltages. The large contacts and screw terminals are well suited for heavy-duty wire up to 10 awg. The gold-plated copper alloy contacts have a typical contact resistance of only 10 mΩ to support high efficiency and low operating temperature rises.

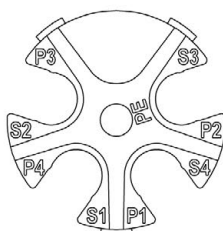
Insulation resistance is another important specification. The unique insert design of EP7 connectors protects the user while maximizing isolation between poles. These connectors have a minimum insulation resistance of 1000 MΩ.

EP7 series models are available in 3-pole, 4-pole and 5-pole configurations and support designers' needs for a single family of connectors that can be used in a range of input power designs (Figure 2). Common voltages used in commercial and industrial lighting systems are 277 Vac single phase (1Ø), 480/277 Vac 3Ø, and 3Ø 208 Vac WYE configuration. The number of poles depends on the electrical configuration. Examples include:

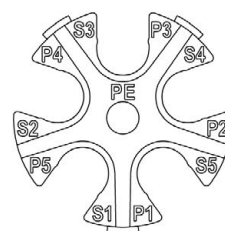
- 3 Pole – The voltage between each phase and neutral in a 480 Vac 3Ø system is 277 Vac. A 277 Vac 3 pole 1Ø connection is easily derived from a 480 Vac 3Ø power configuration.
- 4 Pole – A 3Ø 4 pole system has three hot wires and one neutral wire. In a 480/277 Vac system, connecting from any hot wire to any other hot wire (line-to-line) will produce 480 Vac, while connecting from any hot wire to neutral will result in 277 Vac.
- 5 Pole – A 3Ø five pole 208 Vac WYE configuration has 208 Vac between phases and can provide 120 Vac (208 Vac x square root of three) between any phase and neutral. The five poles are the three phase voltages, a neutral and a ground, with the neutral and ground bonded together to comply with the U.S. National Electric Code (NEC).



3-POLE



4-POLE



5-POLE

Figure 2: Physical configuration of the poles in EP7 series power connectors where P = pin contact, S = socket contact and PE = protective earth, (Image: Switchcraft)

MECHANICALLY FLEXIBLE AND ROBUST

Once the environmental and electrical performance of the connectors has been assured, it's time for packaging and system integration. Mechanical flexibility and robustness are areas where EP7 power connectors shine.

The terminal screws and springs are stainless steel for long life and high reliability. The Insta-Click™ spring loaded latching mechanism locks automatically. And the latching mechanism provides positive lock while improving the water resistance rating to IP68 when used as part of a molded cable assembly. The connector latch can be manually disconnected with a simple quarter turn of the coupling ring, speeding device replacement and maintenance.

These connectors are rated for a minimum of 400 insertion / withdrawal cycles with a 10 lb. [44.5 N] maximum operation force for insertion or withdrawal. And they meet Mil-Std 202G vibration requirements. They are offered in cable-end, panel-mount and cable-to-cable configurations to meet the connectivity needs of any application (Figure 3). Custom over molded cable assemblies are also offered.

CONCLUSION

Selecting power connectors for use in demanding environments can be a complex undertaking with numerous factors to consider. The connectors need to meet strict IP ratings and be made using materials rated F1 per UL 746C. They must be rated for at least 600 V AC and DC per UL 2238 and be able to efficiently conduct at least 30 A. The EP7 series power connectors from Switchcraft are USA-made, meet all those requirements, and more.

EP7 connectors also support designers' needs to implement a range of electrical power architectures like 277 Vac 1Ø, 480/277 Vac 3Ø, 3Ø 208 Vac WYE, and so on. These connectors are also mechanically flexible for various system implementations and robust to support high reliability over several hundred insertion / withdrawal cycles.

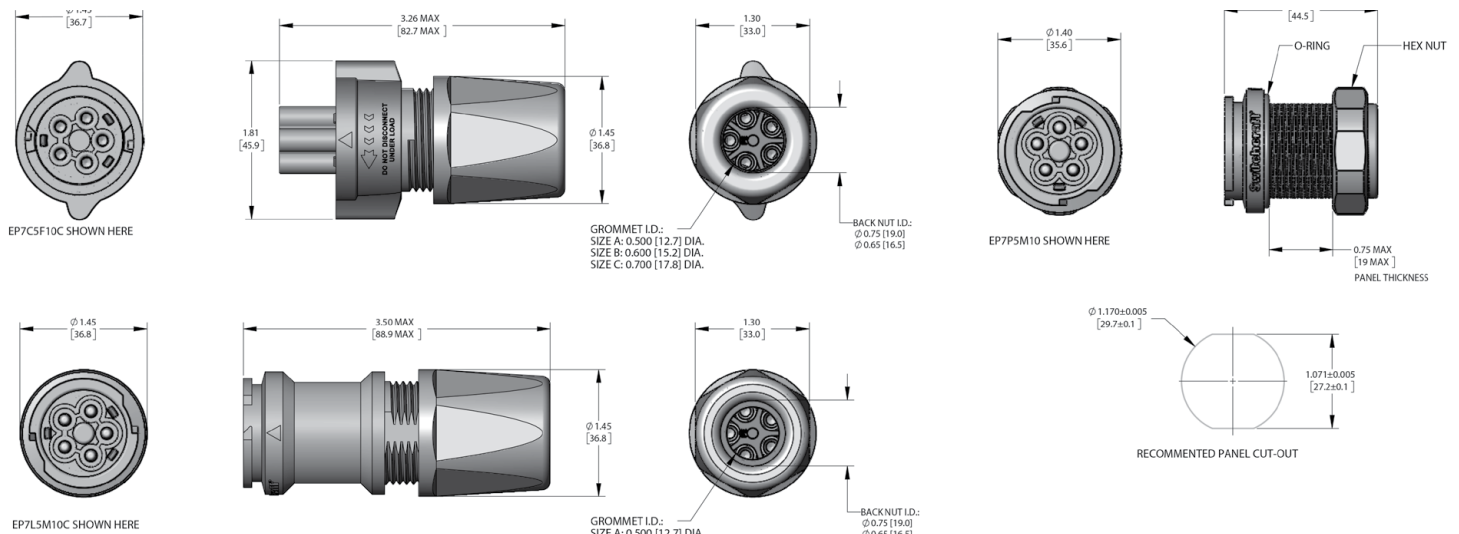


Figure 3: EP7 power connectors are available in cable-end (top left), panel mount (top right) and cable-to-cable (bottom) configurations to support any system design. (Image: Switchcraft)