WHITE PAPER

THE INCREASING IMPACT OF DATA SPEED AND MINIATURIZATION ON RUGGED CONNECTOR SELECTION

EDITION 1.0 | FEBRUARY 2018

fischer® CONNECTORS

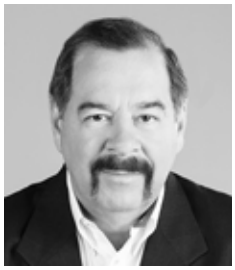
REIMAGINING CONNECTIVITY TOGETHER

THE INCREASING IMPACT OF DATA SPEED AND MINIATURIZATION ON RUGGED CONNECTOR SELECTION

THE NEW STEP-BY-STEP GUIDE FOR RUGGED CONNECTOR SELECTION

Connector selection has morphed from the old standby "how many contacts do you need" to a much more serious challenge for design engineers who need to find ways to pump increasing amounts of data through smaller and smaller spaces. With usability experts adding their ideas into the mix, there are additional challenges with connector selection that often mean figuring out how to run electrical and signal in one connector/cable combination without interference.

All this creates new priorities when you start your connector selection process. With that in mind, we've updated our step-by-step rugged connector selection guide for the new realities engineers face today.



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David Cianciolo is the Director of Engineering at Fischer Connectors, Inc. His electro-mechanical education and 30+ years working with medical device design and military connectors make him uniquely qualified to lead the US design team in interconnect design and assembly, including the critical pursuit of proper cable selection. Dave has been granted several design patents through his career. Focused on custom sealed durable interconnect solutions in rugged environments, David and his team are currently building innovative interconnect solutions for high speed data connectivity and sealed military and medical applications, in addition to molded sterilizable silicone cable solutions for our medical customers.

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When you know your connector will be exposed to the elements, sterilized, or continuously mated and unmated, you need to look at a larger set of variables than a typical consumer-grade connector. Variables continue to morph as technology evolves, so we have taken a fresh look at what engineers should be asking and looking for in their next rugged connector solution.

1. ELECTRICAL NEEDS

Step one doesn't change because physics hasn't changed! Defining the electrical voltage and current requirements each contact will carry is still the first step to selecting the ideal connectors for your device. You have to ensure that you not only have the right number of contacts, but that the contacts can carry the power and signal demands of your application. The size of the contact and the size of the wire dictate the current-carrying capability of a contact. Contact spacing, insulation materials, and the geometry of the insulator used to isolate the contacts dictates the voltage rating.

To ensure you design in the proper connector, dig deep to understand how a manufacturer specifies their connectors' current ratings and operating voltages. Their test data should reference a test standard, informing you exactly how their testing was conducted. Not everyone uses the same testing criteria, so ensure you understand how these specifications were derived.

When you are reviewing current ratings, take note of the «temperature rise» specification. This specification indicates how much heat will be dissipated at a specific current value. You also want to confirm that the contact will support the conductor size you have selected. A non-compatible conductor could cause overheating issues, leading to premature connector failure. (See Table A)

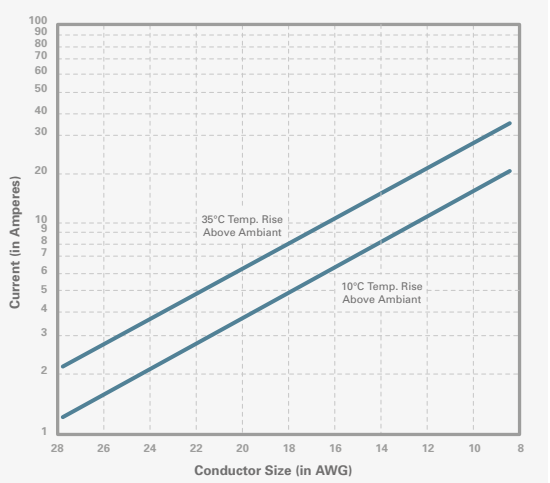
Table A

Nº. of conductors	Factor*
1	1.6
2 to 3	1.0
4 to 5	0.8
6 to 15	0.7
16 to 30	0.5

** Multiply the amperage value by this factor to find the recommended current capacity.*

Note: Current ratings are intended as general guidelines for low power electronic communications and control applications.

Current ratings for power applications generally are set by regulatory agencies such as UL, CSA, NEC, and others.



2. DATA SPEED

Focus on data speed has increased significantly in the past few years, with devices expected to communicate massive amounts of data via specific protocols, over local area networks and through the Internet to other connected devices. Often, when it comes to critical applications that rugged connectors are used in, the data transfer not only has to be accurate without interference, but it has to be fast enough to trigger actions in fractions of seconds to ensure the safety of equipment and people. When designing for data speed, we recommend two rounds of design and testing, using software first, then moving to testing the chosen connector/cable combination.

Design simulation and testing

Designing a connectivity solution for a specific data protocol requires optimizing the design of both the connector and the cable. The first condition for a functional solution is to have a connector that is capable of handling a specific protocol.

Characterization & Qualification

Once the design has been optimized for a defined protocol, a physical product prototype needs to be tested to validate the full characterization using a Network Analyzer.

S-parameters of the cable assembly are measured and compared with the target values defined in the protocol specification (e.g. USB 3.0, HDMI, Ethernet). If one of the parameters fails, an iteration loop will be made on the design until the cable assembly fulfills all protocol requirements. At this time, the product can be declared "protocol compatible".

International standard ISO/IEC 11801 specifies general-purpose telecommunication cabling systems (structured cabling) that are suitable for a wide range of applications (analog and ISDN telephony, various data communication standards, building control systems, factory automation). Balance cabling performances are defined by a set of multiple parameters. The most relevant are Insertion Loss (IL), Return Loss (RL), Near End Crosstalk (NEXT) and Far End Crosstalk (FEXT).

When it is critical that your rugged interconnect solution achieves a certain speed such as USB 3.0 (5 Gbit/sec), you should work with your connector suppliers to get specific cable recommendations. It will save you the trial and error that we have already gone through to find the solutions you need.

3. TERMINATION TYPES

After you look at electrical and data transfer needs, it's time to determine how you want to terminate your connector. It's an important detail because termination types have a direct effect on the assembly process and the ability to seal a connector.

Connectors with solder contacts are typically easier to seal against moisture ingress, while crimp contacts may offer better field reparability. There is a trade-off between the two, so the final decision on which termination type to use is often made after discussions with your manufacturing and design groups. It's important to know exactly how and where the connector will be used, and whether field reparability is a requirement, as this decision has a significant impact on the assembly equipment and processes used in manufacturing.

4. ENVIRONMENTAL OR HERMETIC SEALING

If the connectors will be used in harsh operating environments, check the manufacturer's IP (Ingress Protection) rating for sealing to dust and water at various depths and operating time frames. Make sure you understand the end use environment for your connectors, and then compare that scenario with the details behind the manufacturer's IP rating.

Most of the IP designations have specific conditions, but the IP68 rating may be defined by each manufacturer differently. When looking for a connector with an IP68 sealing rating, inquire exactly how the manufacturer's IP68 rating is measured. A system being submerged at 2 meters for 24 hours has a different impact on the connector than at 120 meters for 24 hours, but both situations can be defined with an IP68 rating. For a vacuum application, you may need a product sealed to a greater level than what is defined by the traditional IP ratings. These are defined as hermetic (airtight) sealed products, and are often used in instrumentation applications.

5. MATERIALS

Steps 5 (Materials) and 6 (Reliability Needs) lead directly into the discussion on miniaturization. Decisions you make with these two steps will directly impact how small you can go with the connector you are specifying. You may need to make some trade-offs in terms of material selection and size, as the smaller the connector you specify, the more you need a strong material to handle the application requirements.

Selecting the housing material wisely is critical, as this will impact reliability, weight, and cost. Brass connectors with nickel/chrome plating are traditionally more wear resistant and have longer lifecycles than many other materials. If weight is an issue, aluminum connectors may be an option. Brass and aluminum are the most preferred materials for miniature rugged connectors. Consider plastics for limited reuse and disposable applications. If you are considering plastic, ensure you conduct adequate testing to confirm it will withstand the end use application. If used in medical applications, make sure your connector will withstand the sterilization processes used by the end customer. For aggressively corrosive environments or some food industry applications, stainless steel may be required. Don't sacrifice reliability for cost when deciding what material you select.

At this point, you should also review the operating temperature of the insulating materials used in the connectors you are evaluating. This includes contact insulators, potting materials and o-rings. Tables B and C can guide you in your selection process.

Table B

O-ring Material	Operating Temp Range	Petroleum/Fuel	Ketones	Wear Resistance	Radiation Resistance
Buna-N (Nitrile)	-35°F to 250°F (-37°C to 121°C)	R	NR	G	F
EPDM	-60°F to 320°F (-51°C to 160°C)	NR	R	G	F
Silicone	-65°F to 450°F (-54°C to 232°C)	NR	NR	P	G
FPM (Viton)	-15°F to 400°F (-26°C to 204°C)	R	NR	G	P

R = Recommended NR = Not Recommended G = Good F = Fair P = Poor

Table C

Insulator Materials	Operating Temp Range	Dielectric Strength*	Radiation Resistance
PEEK	-85°F to 392°F (-65°C to 200°C)	18 kv/mm	10^9 Rad
PTFE	-85°F to 320°F (-65°C to 160°C)	20 kv/mm	10^4 Rad
PBT	-85°F to 275°F (-65°C to 135°C)	17-30 kv/mm	10^8 Rad

** IAW IEC 60243-1*

6. RELIABILITY NEEDS & CONNECTOR CHARACTERISTICS

Now that you've investigated the electrical, termination, sealing, and material requirements, it's time to take a look at the frequency your user will connect and disconnect the device over its lifetime. If you require a very high number of mating cycles, consider a connector with 5,000 to 10,000+ mating cycles. This is especially important if a failed electrical connection can put lives at risk, such as in the medical or military environments. There may be trade-offs to consider between miniaturization and number of mating cycles, as miniaturization often means fewer mating cycles.

Another requirement to have a look at is whether your connector will be able to stay stable in harsh and extreme environments. Many connectors work for example well indoors, but they will lose their performance when they are used under extreme outdoor conditions. It is therefore important to make sure that your connector is suited for use under these harsh and extreme conditions when needed.

The following table D contains information about various characteristics you should consider when selecting rugged connectors.

TABLE D

Characteristic	Considerations for rugged connectors
Sealing	Environmental sealing: IP68 or higher, submersible – Hermetic sealing $1x10^{-5}$ mbar l/sec or better
Mating Cycles	5,000+
Materials	Nickel/chrome plated brass – Aluminum
Durability	Harsh environment, resistant to abrasion, chemicals, corrosion, impact or shock
Temperature	-58°F to 320°F (-50°C to +160°C)
Keying	Features to prevent mis-mating. Color coding and blind mating features are desirable
Locking	Push-pull, breakaway, twist lock, screw type
Accessories	Sealing caps, Protective boots
Shielding	EMI/RFI, 360 degree

7. MINIATURIZATION

Everything we've discussed so far will impact how small you can go with your miniature connector, and what level of functionality you can demand from it. There is not a single industry out there today that isn't demanding that equipment get smaller, lighter and more functional at the same time. Connector design and selection should be addressed early in the design process to take advantage of the newest, smallest designs available to you.

There are some great things going on with miniaturization today, and you should take advantage of it where you can. It is possible to design in one connector today for an application that would have needed two or three connectors only a year ago, but you have to be careful. Look closely at the details in each connector, since those details become more important as the voltage and current increase. Compare models for pin size, number of pins, and functionality. Miniature connectors are nice packages that fit in small places, but only a few can carry both power and signal. If the pin size is too small, it may not carry the power you require, or signal may be more susceptible to interference. As the connector package gets smaller, so does the withstand voltage. In addition, these small connectors are extremely difficult to terminate, so often the miniature plugs and receptacles are sold pre-wired to maintain reliability.

Combining miniaturization and data speed is tricky, and only partially because of connector design. If your supplier claims that a connector can deliver data at a certain speed, ask for test data. Suppliers should be able provide evidence of achieving certain data speeds and supporting protocols such as USB, Ethernet or HDMI, and suggest appropriate cable designs, or provide fully assembled connector/cable solutions. Always remember that the connector and cable together must deliver the speed for the miniaturization solution to make sense for your application. We have seen cases where the cable and connector both passed independent speed tests, but did not work well when put together.

8. SUMMARY

As you work with your fellow designers to build smaller, more functional devices, following the above steps will get you started. There are lots of details behind the main bullet points, especially when you start digging into all the options surrounding cable assemblies and how data speed and miniaturization complicates connector selection. Cable suppliers are coming around to the data speed needs, but selection is still limited and we continually research new cable solutions that will enhance our connector solutions. Remember that rugged connectors are usually custom built when you place an order. You will find some on the shelf, but be prepared for lead times that are a bit longer than a commercial grade connector. On the plus side, you will likely find more personal assistance and engineering help at a company that focuses on rugged connector applications, so you may be able to shorten your learning curve a bit.

FISCHER **MINIMAX™** SERIES

The Fischer MiniMax™ Series is an example of a miniature connector that combines signal and power while maintaining rugged characteristics. Special contact blocks are designed to provide high speed data transfer as fast as USB 3.0 and/or 10 Gb/s. IP68 rating: up to 20 Meters for 24 hours.

FISCHER **ULTIMATE™** SERIES 07

The UltiMate 07 connector is another example of a small, rugged connector. With up to 10 contacts, this small, rugged connector is capable of up to 10,000 mating cycles. With proper cable selection, Fischer UltiMate™ Series connectors are capable of running high speed data for nearly any application. IP rating: up to 120 meters for 24 hours. Custom connector solutions can go deeper.

FISCHER **FIBEROPTIC** SERIES

When you are running a great deal of data over long distances, nothing beats fiber optic connections in terms of speed and bandwidth. Fischer Connectors' single fiber connector is an example of a small, rugged connector designed to allow fiber to go places it hasn't been used in the past. IP rating: 2 meters for 24 hours.

FISCHER **CORE** SERIES

The Fischer Core Series 102 is another example of a small rugged connector capable of running high-speed data. IP rating: 2 meters for 24 hours. Custom connector solutions can go deeper.

ABOUT FISCHER CONNECTORS

Fischer Connectors has been designing, manufacturing and distributing high-performance connectors and cable assembly solutions for more than 60 years. Known for their reliability, precision and resistance to demanding and harsh environments, Fischer Connectors' products are commonly used in fields requiring faultless quality, such as medical equipment, industrial instrumentation, measuring and testing devices, broadcast, telecommunication and military forces worldwide.

Primary design and manufacturing facilities are located in Saint-Prex, Switzerland, with subsidiaries and distributors located worldwide.

Fischer® CONNECTORS

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