Another EMC resource
from EMC Standards

Constructing I/O panels for shielded rooms

Helping you solve your EMC problems

1 Brassey Road, Old Potts Way, Shrewsbury, SY3 7FA T:+44 (0) 1785 660 247 E:info@emcstandards.co.uk

Constructing I/O panels for shielded rooms

Question:

‘We are building our own in-house DIY EMC test chamber for testing simple relative radiated measurements. We want to be able to see if certain design choices affect the EMC performance of our products without having to go to a full testing facility every time. I found some of the material in chapter 4 of the "Design Techniques for EMC" very helpful, but was wondering if you have some material specific to the filtering of power and signals into such chambers?

I have been tasked with designing the Input/Output (I/O) plate of the chamber, where we want to feed in 230V, Ethernet, USB, RF and other signals, but I struggle with grasping all the various filter options available, since there are such a multitude of filtering options to choose from.’

Answer:

To help identify the subject of this blog, here are some photos of I/O panels in shielded chambers:

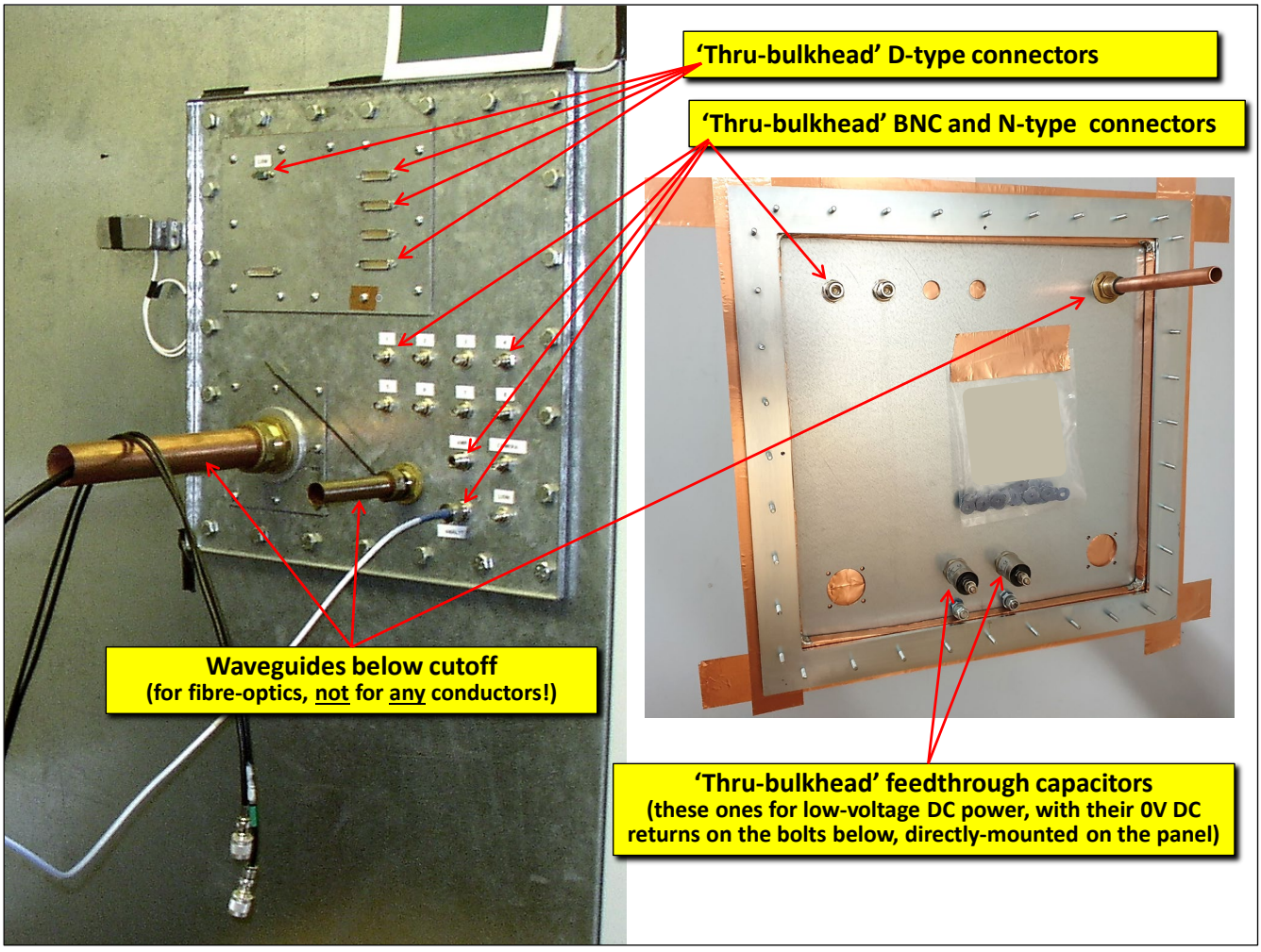

Figure 1
The right-hand photograph is of an I/O panel under construction.

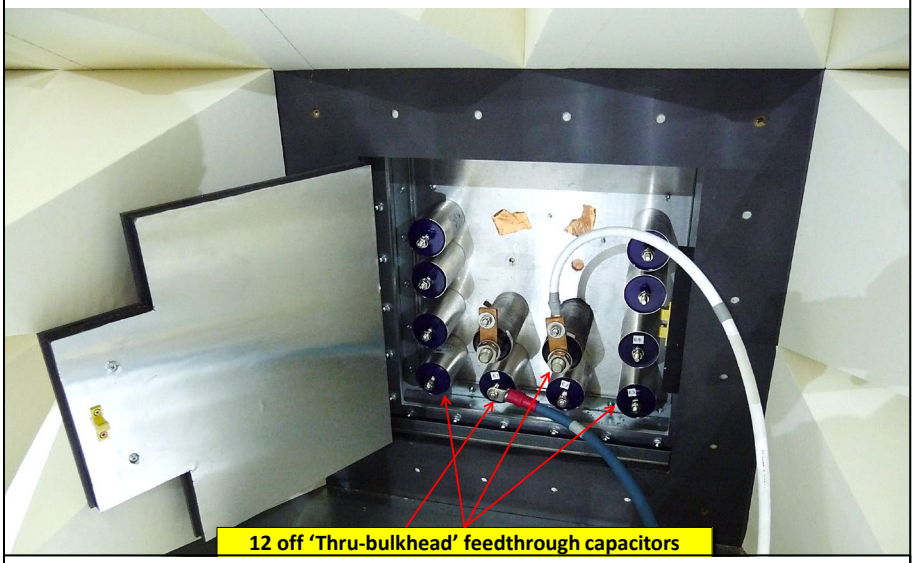

Figure 2

An I/O panel viewed from inside its ferrite-lined shielded chamber.

It has a hinged door covered with ferrite tiles, which is closed as far as possible during testing.

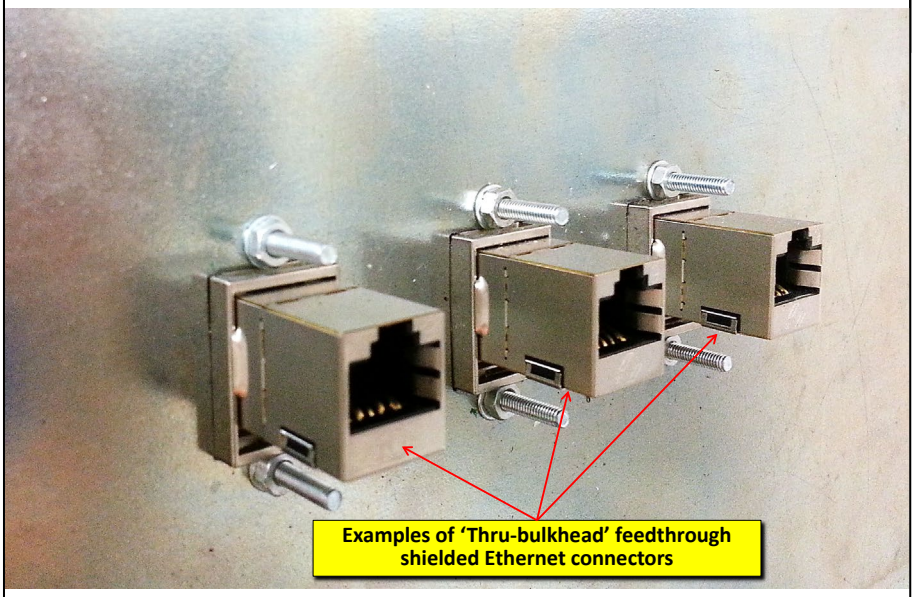

Figure 3

Examples of 'through-bulkhead' RJ45 connectors for Ethernet, mounted on an I/O panel in an EMC shielded room.

There are four ways to get power, data, signals, etc., into a radio-frequency (RF) shielded chamber through an I/O panel without destroying the shielding effectiveness of its external surfaces (i.e. its walls, floor, or ceiling):

1) Conducted via filters, which must be 360° shield-bonded to the surface of the I/O panel (either on its inside or outside). See Figure 4.
2) Conducted via shielded cables, which must be 360° shield-bonded to the surface of the I/O panel (either on its inside or outside). See Figure 4.
3) Radiated via RF in waveguides, which must be 360° shield-bonded to the surface of the I/O panel (either on its inside or outside)
4) RF-modulated light in free space or guided by optical fibres, passing through a waveguide-below-cutoff, which is a metal tube that must be 360° shield-bonded to the surface of the I/O panel but can be protrude from the panel entirely on its outside, entirely on it inside, or anywhere between those two extremes.

Note that any and all other conductors – including all non-electrical metal conductors such as pipes (e.g. for water, gas, fumes, pressurised air, hydraulic fluid, etc.), HVAC conduits, whatever, and plastic pipes carrying conductive liquids (e.g. water, saline fluid, blood, etc.) – entering a shielded room, must be directly bonded to the chamber's shielding surface at the very point where they pass through it. See Figure 4.

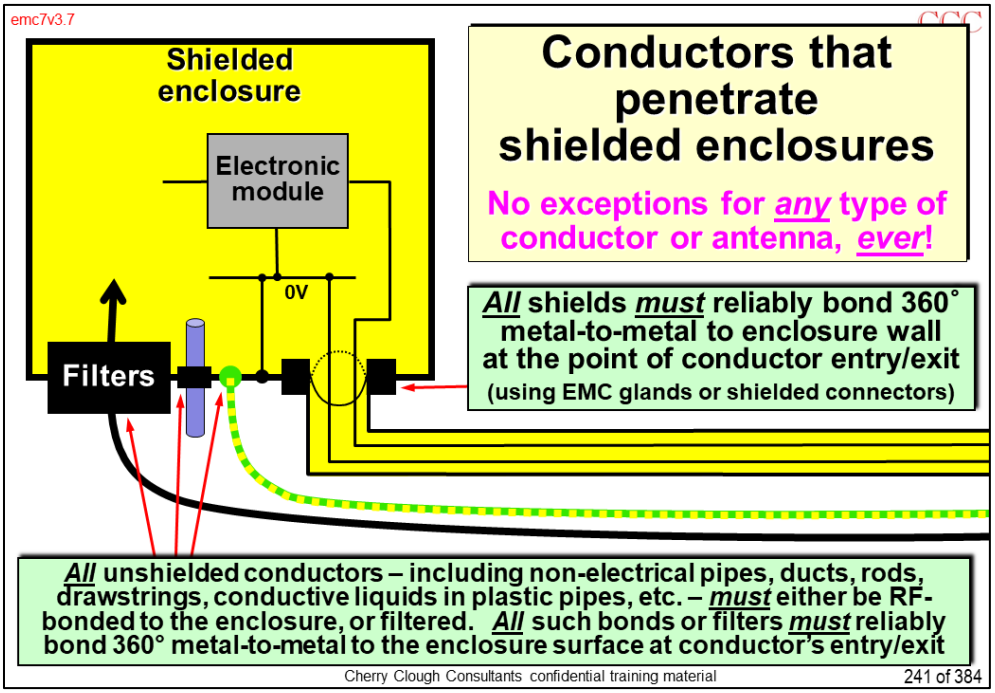

Figure 4

360° shield-bonding

You will have noticed that "360° shield-bonding to the surface of the I/O panel" is a necessary feature of all the above four methods.

Ignoring this, or not doing it well-enough, will compromise the shielding effectiveness of the chamber. How to do 360° shield bonding is described in practical detail in:

- Section 2.6 of my free article published in 2009, available at: https://www.emcstandards.co.uk/files/part_2_text_and_graphics_21_may_09.pdf
- Section 4.6 of my book published in 2010, which can be bought on-line at: https://www.emcstandards.co.uk/emc-design-techniques
- Section 2.6 of my up-to-date training course module, the coursenotes for which can be bought on-line, as a PDF, at: https://www.emcstandards.co.uk/2-emc-in-interconnections-techniques-for-cables

Filtering

How to do filtering is described in practical detail in:

- Section 3 of my free article published in 2009, available at: https://www.emcstandards.co.uk/emc-techniques-in-electronic-design-part-3-filt
- Section 5 of my book published in 2010, which can be bought on-line at: https://www.emcstandards.co.uk/emc-design-techniques
- Section 2.6 of my up-to-date training course module, the coursenotes for which can be bought on-line, as a PDF, at: https://www.emcstandards.co.uk/filtering-for-emc

As the above links explain, there are many different kinds of filters, and not all of them are suitable for fitting on the I/O panel of a shielded room.

The following 6 figures show some types that are suitable.
Many of those shown are military types, but civilian equivalents are available.

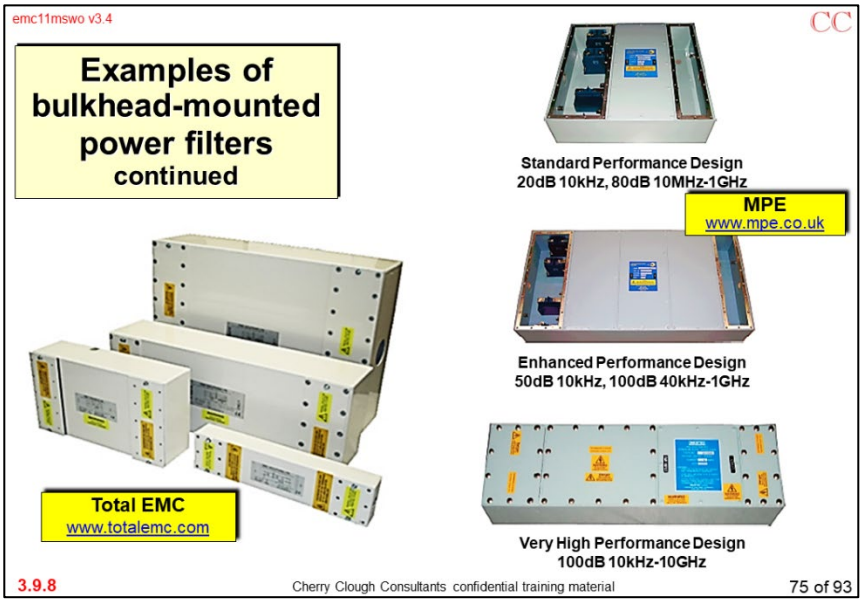

Figure 5
A typical style of 'Room Filter' for mounting directly on the wall of a shielded chamber.

A short, shielded conduit feeds the filtered mains power from the 'room filter' directly through the wall into the chamber.

This style is usually used for single-phase or three-phase 230V mains power, but various signal or data filters may also be available. They are usually too large for fitting on an I/O panel.

Figure 6

An example of a number of 'room filters' for carrying mains power plus a number of audio, video, and data signals, through the wall of a shielded chamber in a medical research laboratory.

Some links for 'room filters':

https://globalemc.co.uk/components/filters/
https://www.mpe.co.uk/category/control-line-filters/
https://www.mpe.co.uk/category/telephone-line-filters/
https://www.mpe.co.uk/category/data-line-filters/
https://www.mpe.co.uk/category/installation-filters/
https://hollandshielding.com/Compact-high-performance-filters-for-shielding-room
https://www.mouser.co.uk/new/epcos/epocs-b84299-shielded-room-filters/
https://www.totalemc.com/GP-Shield-Room-EMC-EMI-Powerline-Filters-id10355.html
http://www.wemctech.com/en/info_show.asp?InfoId=123
https://www.emc-emi.com/EMI-EMC-filter
https://www.theemcshop.com/564-emc-chamber-filters
https://www.tdk-electronics.tdk.com/en/530098/products/product-catalog/emc-components/emc-filters-for-shielded-rooms-epcos-

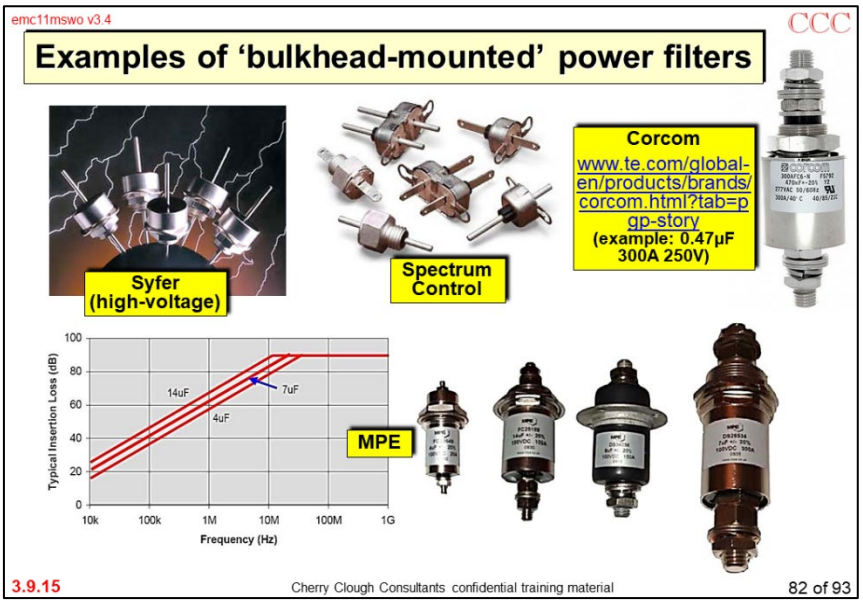

Figure 7

"Thru-bulkhead mounting" is a common term for filters or connectors intended to be mounted directly on the I/O panel of a shielded chamber (or a metal wall of any shielded enclosure).

Figure 8

"Feedthrough" is a common term for filters and capacitors with three terminals:
i) an input terminal on one side of the shield;
ii) a 'ground' terminal (the flange that directly connects with the metal shield surface),
iii) an output terminal on the other side of the shield.

Feedthroughs are intended to be "thru-bulkhead mounted" on an I/O panel of a shielded chamber, or on any metal surface of a shielded enclosure. Here are some examples from Schaffner.

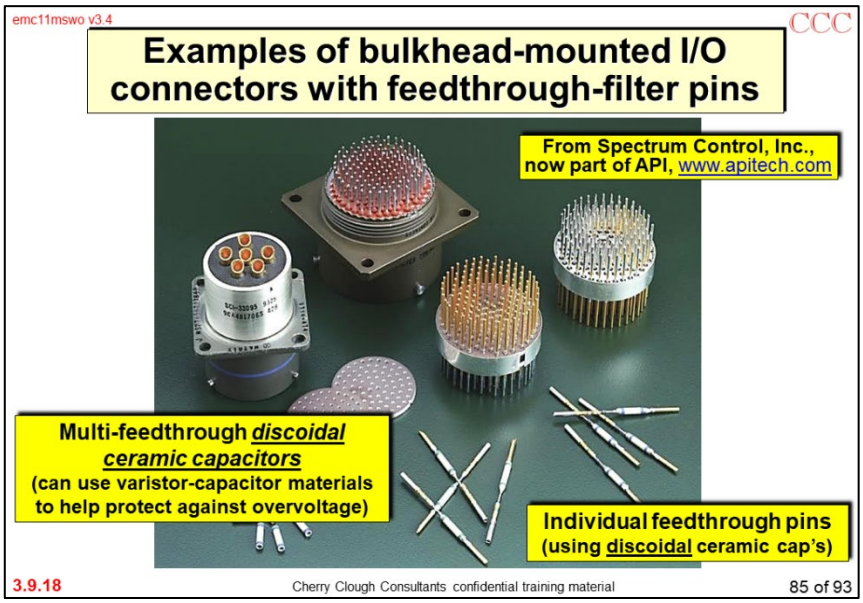

Figure 9

Some examples of customisable bulkhead-mounting multi-way connectors from API.

The pins can be feedthrough capacitors or feedthrough filters, either with or without transient suppression.

Some links for bulkhead-mounted filters and feedthrough capacitors:

http://ap-flyer.pl/wp-content/uploads/Comtest_Chamber_Accessories.pdf

https://www.mpe.co.uk/category/feedthroughs/

https://www.schaffner.com/products/emcemi/ (scroll down to the 'Feedthrough' section)

https://www.globalspec.com/ds/1860/areaspec/mounting_bulkhead

http://www.avx.com/products/rfmicrowave/filters/chassis-mount-feedthru/cylindrical/

https://www.oxleygroup.com/user_uploads/oxley--emi--catalogue.pdf

https://www.knowlescapacitors.com/getattachment/Products/EMI/EMI-Filters/Panel-Mount-EMI-Filters/Knowles-EMI-catalogue-4-11-Pages.pdf

https://www.mouser.com/datasheet/2/18/12-120-16785.pdf

https://www.routeco.com/en-gb/shop/power-conditioning/emc-emi-filters/fn7611-32-m4

https://nextek.com/markets-solutions/electric-hybrid-vehicles/

https://www.te.com/commerce/DocumentDelivery/DDEController?Action=showdoc&DocId=Catalog+Section%7F1654001_CORCOM_PRODUCT_GUIDE%7F0611%7Fpdf%7FEnglish%7FENG_CS_1654001_CORCOM_PRODUCT_GUIDE_0611.pdf%7FCAT-C8114-N1%20 (from page 225 in this catalogue)

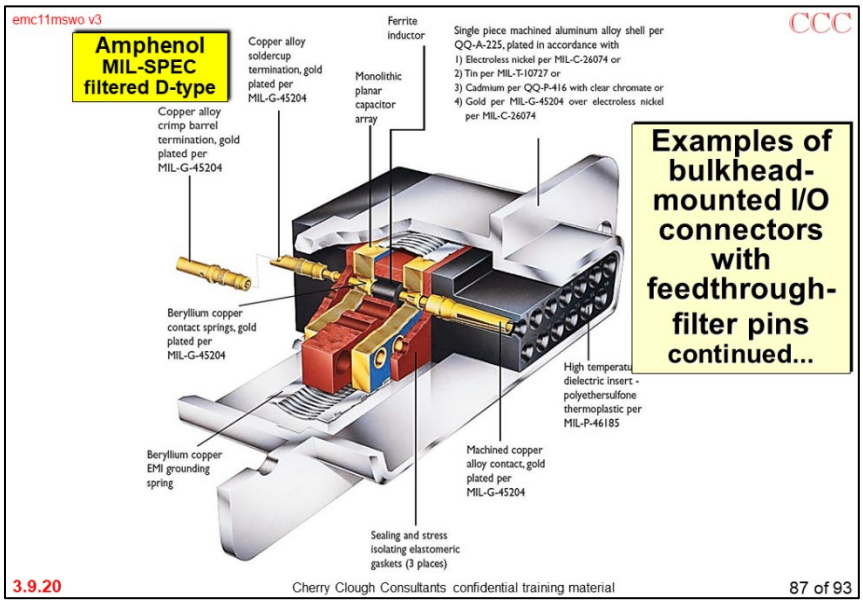

Figure 10

An example of a very high-spec shielded D-type. Its pins can be feedthrough capacitors or filters as in Figure 8.

All connectors with square or rectangular mounting flanges will need 360° conductive gaskets when fitted to the I/O panel of a shielded chamber, or to the metal wall of any shielded enclosure.

Note that circular connectors and filter mounting flanges usually benefit from conductive O-rings too.

Some links for through-bulkhead filtered connectors for data:

https://www.ramayes.com/Ramsey_Test_Enclosure_Connectors.htm

https://raymondemc.ca/products/chamber-accessories/feedthroughs/

https://www.raymondrf.ca/products/products6d.htm

http://www.ramseyelectronics.com/specsheets/STEHDMI2.pdf

https://www.ramayes.com/RF_Shielded_Room_Ethernet_Filter.htm

http://www.amphenolmao.com/Literature/View/BulkheadFeedthrough

Fibre-optic data connections through I/O panels, using 'waveguides below cutoff'

Ethernet, HDMI, and other high-data-rate cables – especially USB – that have to connect equipment inside a shielded room to equipment outside that room, cause big problems for immunity testing.

Especially USB, because the immunity test standards assume all USB cables are very short and only connect to thumb/pen drives or other small 'floating' items – so they don't test them for EFT/B. But in fact, USB is now used to connect items of equipment, but when testing such systems the USBs often fail. It's a big problem for EMC test labs.

The best solution for any data cables that have to enter/exit a shielded test chamber is to:

a) Install a galvanically-isolated optically-based data isolator on the I/O panel, that has provides regular data connectors on the inside and outside of the panel.

b) Fit fibre-optic converters to the data cables in the shielded room and feed the metal-free optical fibre cables out of the room via through a waveguide below cutoff (see Figure 1).

Some links for *panel-mounted* optical data isolators

https://www.djmelectronics.com/usb-emi-rfi-filter.html

https://www.djmelectronics.com/gigafoilv4-inline-ethernet-filter.html (not panel mount type)

Some links for fibre-optic cable converters
(the optical fibre cable is routed through waveguide below cutoff)

https://ppmtest.com/products/fibre-optic-links/fibre-optic-links/ (intended for EMC testing)

http://www.pontis-emc.com/emc-shielded-converters.html

https://www.antaira.com/products/serial-to-fiber

https://www.omnitron-systems.com/products/fiber-media-converter.php

https://www.lindy.co.uk/networking-c5/media-converters-transceivers-c265

https://www.lindy.co.uk/usb-c4/fibre-optic-t818

https://www.lindy.co.uk/audio-video-c2/extenders-c181/300m-fibre-optic-hdmi-10-2g-extender-p10062

To design waveguides below cutoff, for example by using regular plumbing fittings from B&Q, so that they don't ruin the room's shielding (as shown in Figure 1), see:

- Section 4.3.11 of my 2009 article, free from:
  https://www.emcstandards.co.uk/files/part_4_text_and_graphics_21_may_09.pdf
- Section 6.3.11 of my book published in 2010, which can be bought on-line at:
  https://www.emcstandards.co.uk/emc-design-techniques
- Section 10 of my up-to-date training course module on shielding, the coursenotes for which can be bought on-line as a PDF, at:
  https://www.emcstandards.co.uk/shielding-for-emc

The question was about filters for shielded rooms, so I am not going to address the following issues in this blog…

Shielded cables

These can use bulkhead-mounted shielded connectors, or cable glands.

Like filters, these must be 360° shield-bonded to the surface of the I/O panel (either on its inside or outside).

Some of the links under "**Some links for bulkhead-mounted filters and feedthrough capacitors" above cover** bulkhead-mounted shielded connectors.

How to do 360° shield bonding is described in practical detail in:

- My free article published in 2009, available at: https://www.emcstandards.co.uk/files/part_2_text_and_graphics_21_may_09.pdf
- Section 4 of my book published in 2010, which can be bought on-line at: https://www.emcstandards.co.uk/emc-design-techniques
- Section 2 of my up-to-date training course module, the coursenotes for which can be bought on-line, as a PDF, at: https://www.emcstandards.co.uk/2-emc-in-interconnections-techniques-for-cables

RF in waveguides

This topic is not covered in any of my articles, books or training courses. But there is plenty of information on using such waveguides in textbooks and articles on microwave communications.