Testing Methods and Outcomes

for F-Connector Interface Adaptation

By Søren Baldus-Kunze, RF Test Lab Supervisor, Corning Optical Communications

Corning Optical Communications has developed a more effective approach to its testing and investigation methods to help it more effectively get to the root of identified connector issues and find the right solutions.

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Søren Baldus-Kunze has over 28 years' experience in the engineering industry. His previous roles include aircraft mechanical engineer, specialising in turbine engines, as well as sales & development and integration of non-destructive testing modalities such as ultrasonics, X-ray and eddy current. He has held his current position at Corning Optical Communications since 2018.

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As with any equipment manufacturer, we have received a lot of input from our customers over the years, which continues to be instrumental in how we refine and develop our products.

A range of testing methods can be applied to identify the root causes of flagged issues, even those that can prove challenging to identify in the first instance. When it comes to looking at how the connector and the mating part connect, traditionally it has been relatively easy to point the finger at the jumper or the connector. This is often the case, but not always.

So, in 2018, Corning Optical Communications developed a more effective approach to its testing and investigation methods that has helped us more effectively get to the root of identified issues and find an ideal solution. Let's run through the findings and see what we did to solve it.

Optimum fit on standard parts

When we did see issues, the most common feedback from customers often attributed this to ingress, but it could also be other issues such as loose connectors, water penetration, a noisy return path or unstable performance.

What we want in the network is an optimum fit between connecting parts. What you see in Figure 1 below is an X-ray of a passive tap with the female port and the male connector, both with flat and aligned surfaces. Ensuring a really good fit between these two is important.

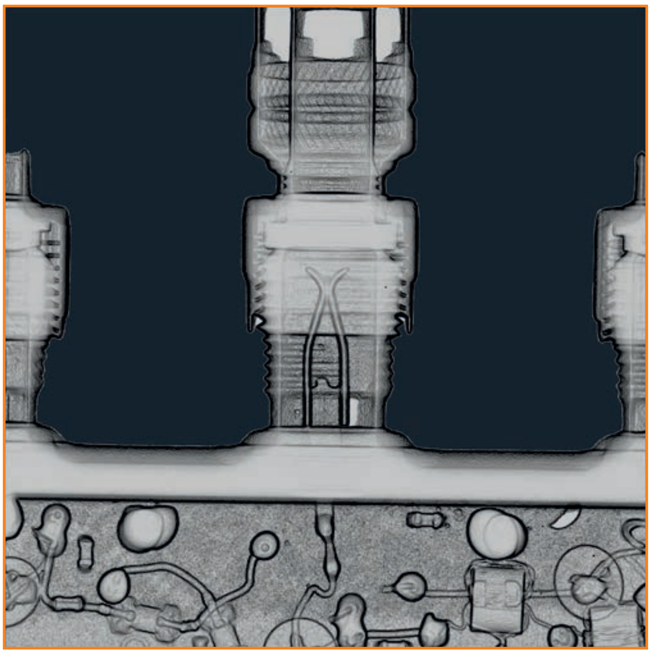

Figure 1

Most of the electrical connection is made through the threaded envelope. However, a lot of the interface matching has a direct effect on the electrical performance. This means that if the front face of the connector does not meet the passive properly, we actually lose performance and get higher ingress or egress.

The differences on the taps of the interface that we need can range from the materials that are used, the hardness, the surface treatment, whether a casting or machine part, whether it meets the standard and (if it, hopefully, does) whether it's a large or small dimension.

In summary, there are many factors which can impact the performance on these vertical parts.

Test methods used in our investigation

The test methods we used in our investigation were extensive and involved all our regular lab instruments: vector network analysers (VNA), time-domain reflectometers (TDR) and our spectrum analysers, for example. In this case, we also used: hardness testing; ultrasonic flaw detection; microscopic pictures; X-ray fluorescence (XRF) for material identification; eddy current testing for conductivity; digital X-rays for cross-sectional viewing of the mating surfaces and, finally, penetrant for coloured signature of the seating area.

We found, mostly, the surface of the port is in poor condition. Major networks tend to use passives and actives of good quality but with smaller network operators, these may be in poorer condition. They could be tilted, off-centred, off-set, scarred or they could even have casting lines.

These "defects" result, in general, in poor matching of the interfaces. Often the F-Connector is not aligned with the port, simply because the port is either very small in diameter or is tilted. This can tend to push the F-Connector or the mating surface to one side, meaning the connection won't have full grip in the threaded envelope.

This can create a gap in one side, which means it will be "RF open", and this can result in the nut tilting. This, in turn, can lead to the nut breaking loose or even tearing the threads, due to the uneven distribution of forces applied. It could also influence the water sealing.

Regardless of the "defect", what we typically find is that our customers will attribute this to ingress.

How we solved the issues

We did a lot of thinking on how we could solve this problem. Of course, it wasn't an option to call a customer and request that they change all their passives to a more reliable material such as machine brass. We needed to figure out a solution that might not solve everything but could, at least, get us to a point where we cover 80% of the issues that we have seen.

Our solution, shown in Figure 2 below, was to develop an insert which employs a conical mating surface. This minor change is still within the F standard and the angle of this has been calculated to give the best possible fit.

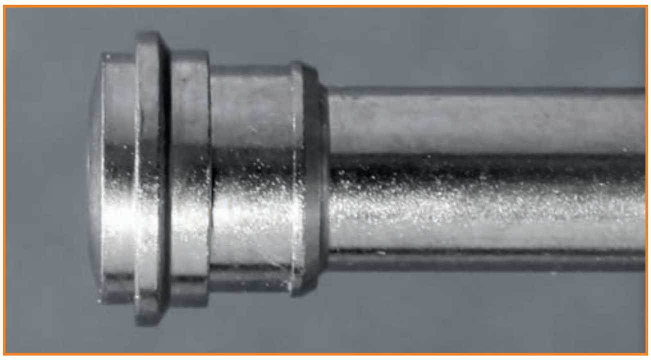

Figure 2

We measured many different taps to ascertain the best possible angle to fit them all, and then made a median line of what we wanted, leading to the shape observed in Figure 2.

The conical interface will self-centre on the counterpart. Even if we have a very tilted interface, it will make a small, material displacement and set itself in the centre. It will even out a defect surface and keep the nut at a more correct angle to the threads as it is self-centring, which creates a sound electrical contact and is also an excellent mechanical fit.

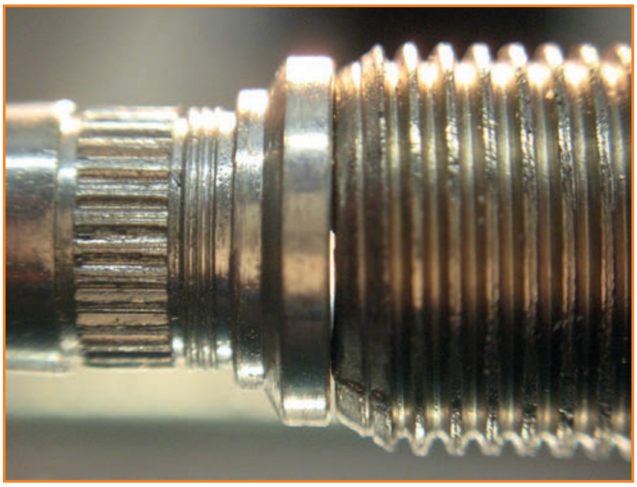

Figure 3

So how does it fit a tap? In Figure 3 above, we see an insert from an F-connector that has been pushed towards the F-port with casting lines. We observe, towards the right of the image, the gap which results when it is left open and untightened.

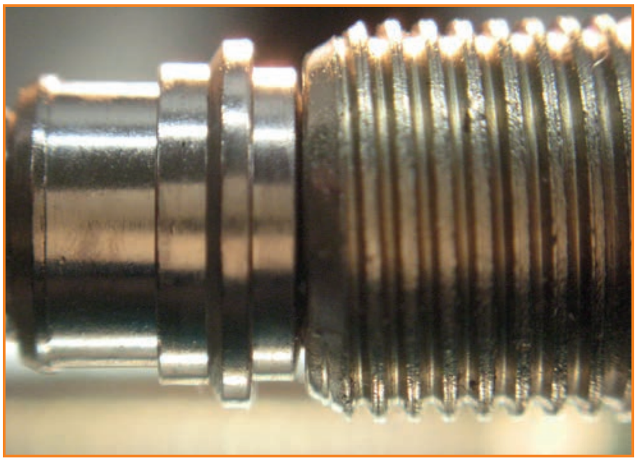

Figure 4

In Figure 4, however, we see the result from using a conical part instead. This evens out the small casting line (where we see the gap in the previous image) and it makes a completely tight connection between the two parts.

As mentioned previously, we also measured DC performance or electrical performance. We tested multiple taps, removing everything except the nut and the insert, with both conical interfaces, flat-face interfaces and with narrow-flat interfaces to assess the differences between these.

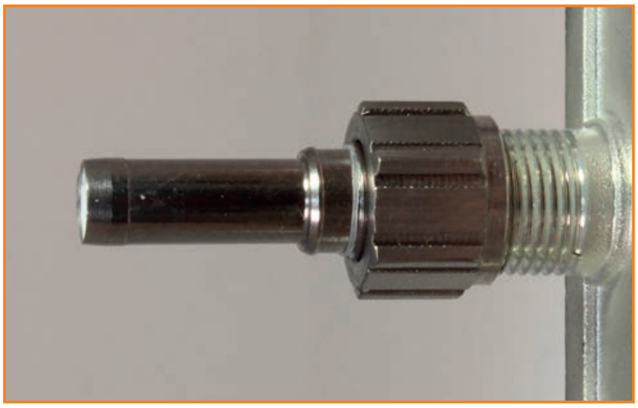

Figure 5

In Figure 5 above, we see that the measuring point was just aft of the nut, as close to the nut as we could get and on the shoulder of the tap on each measurement.

Now for the results. In Figure 6 opposite, we see our large flat interface (the pink column), the narrow flat interface (the purple column) and the conical interface (the blue column) with the resistance measured in Milliohms. We can see that the DC resistance is much lower on the conical face, simply because this mates very well into the material.

We also conducted a rotational test to see whether we could break it loose more easily. These results can be seen in Figure 7, demonstrating the rotational torque at which each of our interfaces will break loose across several taps. Electrically, in terms of DC resistance and mechanical fit, we can see that the conical interface performs very well again. This is further illustrated by the graph in Figure 8 overleaf, which demonstrates much lower screening attenuation and transfer impedence when the conical interface is used.

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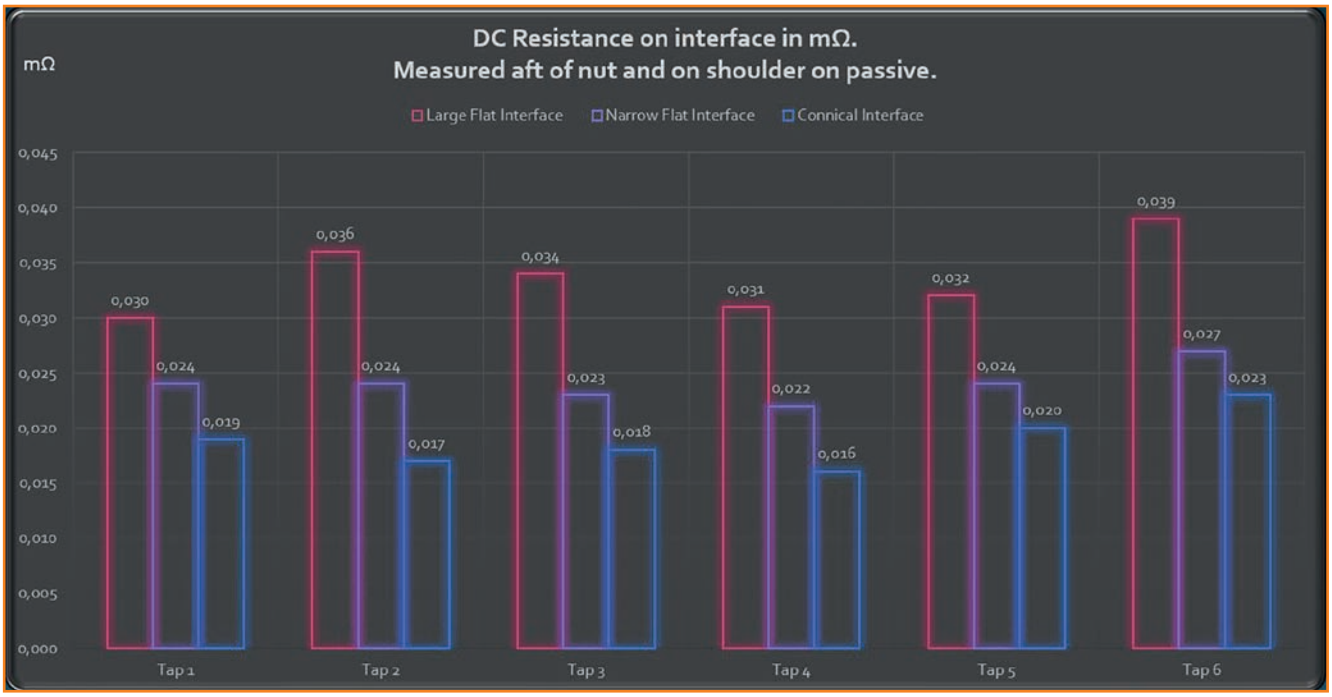

Figure 6

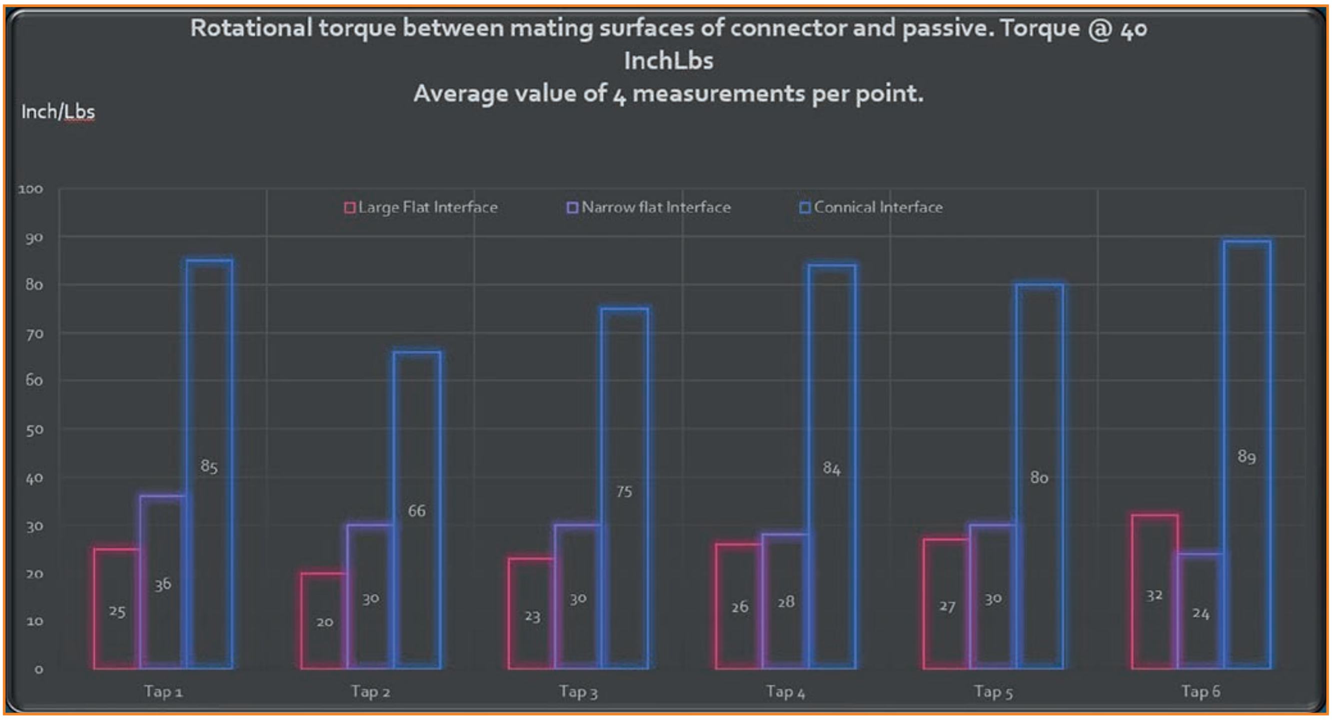

Figure 7

For the purposes of keeping this article concise, I have focused primarily on the resistance testing. However, it is worth noting that we also completed a number of additional tests, including the effect that coupling attenuation on a port with casting lines has on a jumper. We used a flat interface connector on a machined F81 – the standard barrel that Corning Optical Communications uses – with one of our standard cables. With a conical interface inclination of 12 degrees, we were able to solve a lot of the issues with the interface matching that we have seen over the years.

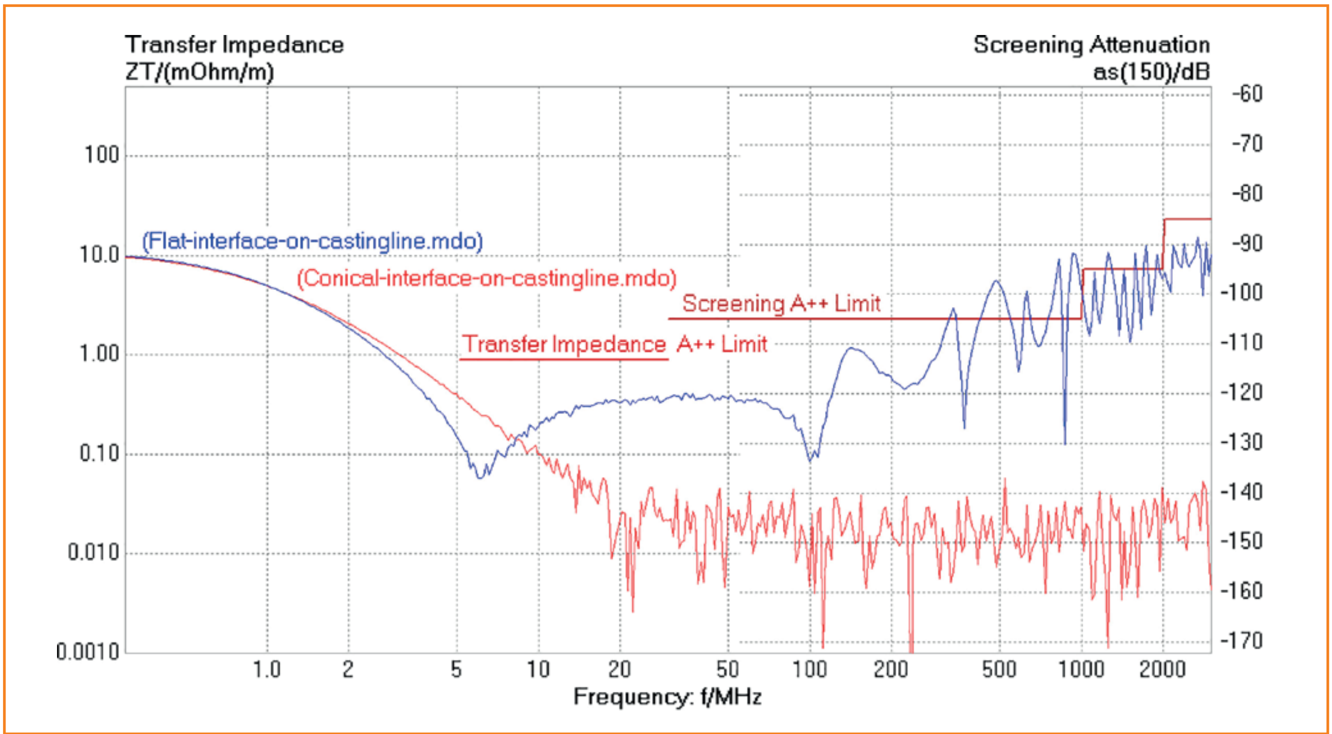

Figure 8

Summary

Simply by using the conical interface, we can solve many of the issues that our customers have experienced. As seen in the X-ray in Figure 9 opposite, it provides a uniform contact surface resulting in very good electrical and RF tight conditions, and its ability to self-centre and make a small material displacement provides an optimum fit.

In addition, it allows the nut a more even distribution of the momentum, keeping the threaded envelope intact. The insert cannot be rotated due to the high friction. It is also more unlikely for the nut to break loose following cable rotations. Ultimately, it delivers optimal performance and fit, regardless of the interface condition.

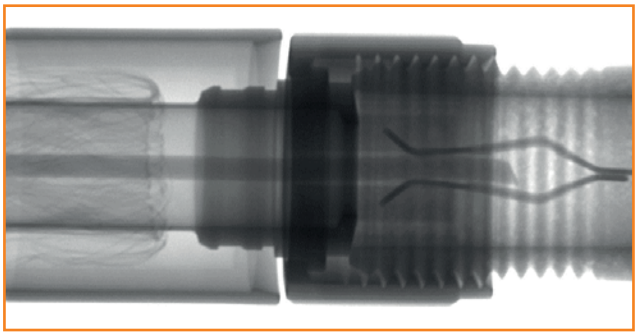

Figure 9