



## Cleaning VSFF Connectors: Protecting Reliability in High-Density Fibre Networks

As fibre networks evolve to meet the demands of cloud computing, AI, and 5G infrastructure, connector technology has had to evolve alongside them. Very Small Form Factor (VSFF) interfaces, such as SN<sup>®</sup>, CS<sup>®</sup>, MDC and LC uniboot have become the new standard for high-density connectivity, allowing far more fibres to be terminated within the same rack footprint. Their compact design supports migration to 400G, 800G, and even 1.6T architectures, but it also introduces new challenges for installation, inspection, and, especially, cleaning.

Industry forecasts suggest the VSFF connector market will grow from around \$50 million in 2024 to more than \$180 million by 2031, a compound annual growth rate of approximately 22 percent<sup>1</sup>. The figures reflect how quickly compact, high-density formats are being adopted as networks move to 400 Gbit/s and beyond. For operators, the ability to increase capacity without expanding rack space is a practical advantage. The trade-off is that smaller geometries leave far less tolerance for contamination, and issues that were once small can now lead to measurable loss or permanent end-face damage.

### Cleanliness and Geometry Challenges

VSFF connectors differ from traditional LC or SC designs through their reduced pitch spacing and miniaturized ferrules, often arranged in uniboot or multi-fiber formats. This enables exceptional density but leaves less clearance between ports, making each end face harder to access. Limited tool space and restricted airflow allow airborne dust and static-attracted particles to settle and remain in place, while the smaller ferrule geometry means even microscopic residues occupy a proportionally larger part of the optical path.

Any contamination, whether dust, oil, or film, can scatter light, increase insertion loss, and raise back-reflection levels that destabilize high-speed transceivers. Under higher optical powers, residues can carbonize, permanently marking the glass. As a result, cleaning and inspection are not just routine maintenance, they are fundamental to ensuring network reliability and protecting costly fiber hardware.

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<sup>1</sup> <https://www.metastatinsight.com/report/global-vsff-connector-market#:~:text=Global%20VSFF%20Connector%20market%20is%20estimated%20to,and%20efficient%20connectivity%20solutions%20continue%20to%20rise.>

## Cleaning and Maintenance Practices

Whether in a data centre, telecom hub or production environment, VSFF cleaning must be treated as a precision process. The combination of small geometries and higher power densities demands controlled methods, consistent materials and clearly defined standards.

- **Specialised Cleaning Tools**

Purpose-built cleaning tools for VSFF connectors include miniaturised cleaning sticks and swabs (1.25mm or smaller) specifically dimensioned for small-form applications. Click-to-clean tools designed for VSFF geometries, such as devices engineered for MPO and similar compact connectors, provide controlled, consistent cleaning in high-volume scenarios. These tools employ precision-engineered cleaning tapes that conform to the reduced dimensions of VSFF end faces while delivering thorough contamination removal.

Touchless cleaning systems are an advanced approach particularly well-suited to VSFF maintenance. These automated devices use precisely directed streams of cleaning fluid and compressed air to remove contaminants without physical contact with the connector end face. By eliminating mechanical contact, touchless systems minimise the risk of scratches or other damage to the delicate ferrule surface while ensuring comprehensive cleaning across the entire end face, extending to the ferrule edge.

- **Wet-to-Dry Cleaning Protocol**

The wet-to-dry cleaning method is fundamental for VSFF connector maintenance. When using manual cleaning methods, this technique typically involves applying a high-purity, static-dissipative cleaning fluid to one section of a lint-free, optical-grade wipe. The connector end face is then cleaned with a controlled swipe from the dampened section toward the dry part of the wipe. This approach effectively removes particulate contamination and oily residues while dissipating electrostatic charge that can attract and hold contaminants.

When using cleaning sticks, dampen the tool with cleaning fluid and rotate it clockwise for 6 to 8 turns. Crucially, each cleaning stick should be used for only one connector end face to prevent cross-contamination between connections. For click-to-clean tools, the fluid should be applied to a wipe first, with the tool then touched to the dampened wipe before insertion into the connector port. Direct application of cleaning fluid to the end face or tool should be avoided.

- **Fluid Selection Considerations**

The choice of cleaning fluid significantly affects VSFF maintenance effectiveness.

High-purity, fast-drying formulations purpose-built for fibre optics are essential. These engineered fluids feature low surface tension that aids in releasing electrostatic charge from fibre end faces while effectively dissolving contaminants. Rapid evaporation rates ensure that no residues remain after cleaning, preventing the introduction of new contaminants or streaking that could compromise optical performance.

### **Electrostatic Effects**

Electrostatic charge (ESD) is an invisible but serious threat in high-density environments. The close spacing of VSFF ports allows static to accumulate quickly on housings and ferrules, attracting dust and lint directly to the optical surface. Once charged, these particles adhere tightly and may not respond to dry cleaning.

At elevated optical powers, charged debris can heat and fuse to the glass, permanently pitting the end face. To minimise risk, static-dissipative cleaning fluids should be used wherever possible to neutralise charge during cleaning. Lab settings should use ESD-safe mats and wrist straps and maintain moderate humidity to reduce charge build-up. Where possible, local air filtration or clean-enclosure practices further prevent airborne contamination.

### **Inspection**

The compact dimensions of VSFF connectors make visual inspection with specialised fibre scopes non-negotiable. Following industry standards such as IEC 61300-3-35, the three-step process of ‘inspect-clean-inspect’ provides essential verification that cleaning procedures have achieved the required cleanliness levels.

A first inspection shows the type and extent of contamination, informing the choice of right cleaning methods. Post-cleaning inspection confirms that end faces are free from residual particles or cleaning fluid deposits. For VSFF connectors, inspection scopes must provide sufficient magnification and resolution to detect contamination on the reduced end-face geometry. Digital inspection systems can provide documentation of connector condition, supporting quality assurance programmes and maintenance records.

### **Success in VSFF Maintenance**

As fiber networks continue to densify and performance requirements escalate, VSFF connectors will play an increasingly significant role in network architecture. The unique characteristics of these compact connectors, both their advantages and maintenance requirements, demand that network operators evolve their cleaning protocols and invest in proper tools and methods. Success in VSFF maintenance requires understanding that connector cleanliness is not just a best practice but a fundamental prerequisite for network performance.

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