TD-00283

Handling of Optical Fibers and Fiber Optical Rotary Joints

1 INTRODUCTION

Operators that are familiar with electronic components and wiring may not be aware of the special needs of optical fibers and fiber optical rotary joints (FORJs). As most optical fibers consist of glass, which is known to be brittle, proper handling of optical fibers is required to prevent fiber damage. Listed below is a set of general rules/guidelines including a trouble shooting that are commonly used to ensure handling procedures that are safe for both the fiber and the operator.

The major components of an optical fiber and responsible for guiding the light along the fiber are the core and cladding. Depending on additional mechanical constituents different fiber types can be distinguished. A bare fiber is protected only by a polymer coating, exhibiting the lowest level of protection and requiring the most attention of proper handling. The bare fiber can be covered with an additional layer of synthetics, making handling more easy and providing further protection. This is then called a buffered fiber. If even higher security measures are necessary cables with e. g. aramid reinforcement can be used. Figure 1 illustrates the structure of a fiber optic cable.

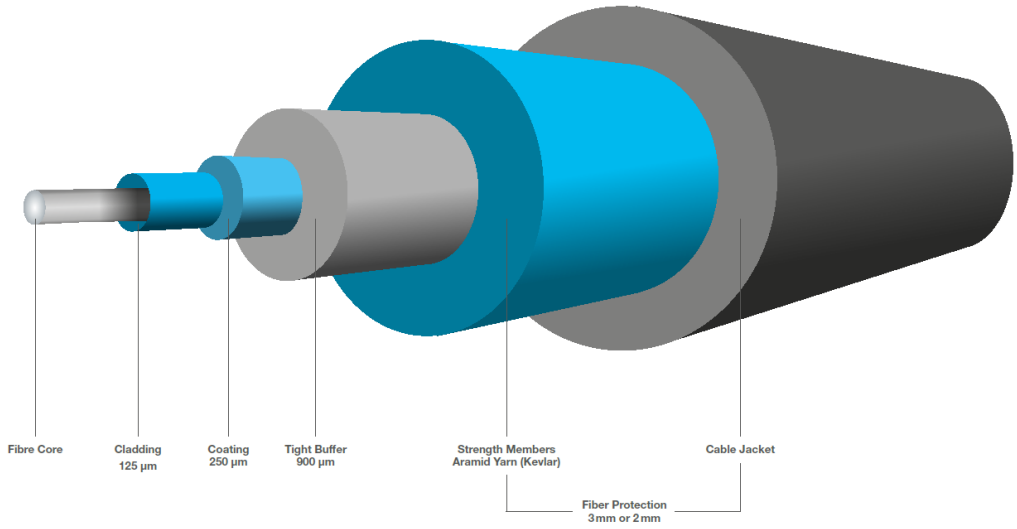

Figure 1: typical elements of a fiber optical cable

Apart from a broken fiber, contaminated fiber optic cables often lead to degraded fiber optical (FO) performance or even failure of the whole system. As such, to ensure that fiber optic cables or FORJs can yield the best possible results of the FO performance it's of great significance for engineers and operators to keep in mind how to handle optical fibers or cables.
The Application Note is treating the fiber handling, safety precautions, fiber endface cleaning, FORJ handling, and give a guideline for troubleshooting.

2 FIBER HANDLING

- Never expose the fiber or cable to a bending radius R less than the *minimum bending radius R_{min} (see Fig. 2)*. The minimum bending radius depends on the type of cable/fiber and are specified in the SPINNER data sheets. Typical values are indicated below:
  - Cables/jackets with diameter more than 1 mm: $R_{min} = 60$ mm
  - Fibers with diameter 900 µm buffering: $R_{min} = 30$ mm
  - Bare fibers with diameter 250 µm coating: $R_{min} < 15$ mm (depending on fiber type)
  - For special fibers or particular requirements please don't hesitate to ask SPINNER company.

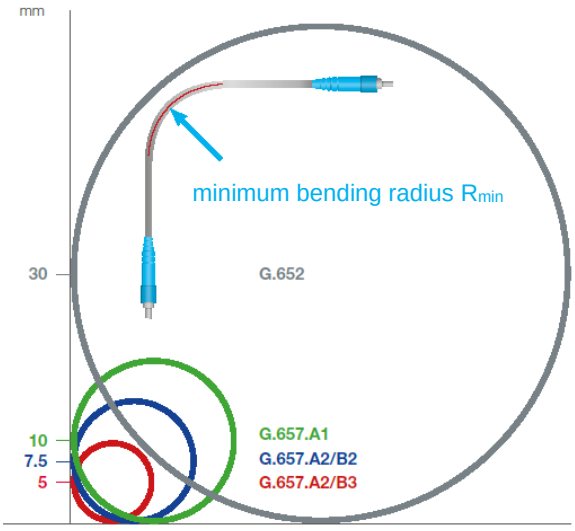

Figure 2: Minimum bending radius R_{min} with depicted bending radii of G.652 and G.657 singlemode fibers.

- Avoid the contact of the fiber with sharp edges (like of optical tables).
- Don’t place hard and heavy items on the fiber.
- Avoid that the exposed fiber end, e.g. the connector’s endface, come in contact with any surface. SPINNER supplies dust caps to protect the ferrules for safe handling.
- Never wipe an optical fiber, especially fiber tips and connector’s endfaces, with abrasive material.
- Do not allow kinks or knots to develop in the fiber. This is in particular relevant when dealing with several fibers at the same time, as is the case with the SPINNER multichannel FORJs. Avoid pulling on the fiber when kinks or knots are already present.
- Avoid pulling on the fiber in general since it may cause severe damage to it. Consider this when unplugging connectors or threading the fiber through your setup.
- Changes to the fiber, like stripping, cleaving or assembling new connectors without consulting SPINNER lead to the expiration of the guarantee.

3 SAFETY PRECAUTIONS

For the operator there are two major risks:

- loose fiber fragments
- laser light

The following safety precautions focus on these issues.
Generally, for products supplied from SPINNER it won't be necessary to cleave or cut a bare fiber. However, we provide safety guidelines for the handling of bare fibers for exceptional cases, e.g. a fiber is broken into 2 pieces.

- Wear safety glasses with side shields to protect the eyes from errant pieces of fiber. Note: Safety glasses provide no protection from laser light.
- Use gloves and wipes to clean the fiber work area.
- Use special debris containers for disposing loose glass fibers and don't use the standard wastebasket.
- Do not touch your eyes or face at any time while handling bare fibers. Wash your hands immediately after working with bare fiber or solvents.
- During activity with loose fibers use wooden seats instead of upholstered ones, as loose fiber pieces can stick in cushion.
- Do not eat or drink in or close to an area where bare fibers are processed. Ingested fibers can cause internal damage.
- Always make sure that the fiber optic cables are disconnected from the laser source prior to visual inspection.

- **Warning!** To prevent serious eye damage, never look directly into a FO cable connector or mating adapter. Never assume laser power is turned off or the fiber is disconnected at the other end.

4 CLEANING

Connectors and bulkhead adapters should be inspected and cleaned before interconnection, as contaminants can damage the connector or degrade FO performance.

The fiber endface and ferrule should be cleaned before mating with its counterpart. Solid contaminants like dust or lint, and fluids like oil or other lipids (e.g. from touching the fiber endface) obscure the fiber endface. Given that the diameter of the core of a typical singlemode fiber is about 9 µm it is not hard to imagine how average dust particles with sizes in the range between 1 – 20 µm can easily degrade the optical signal when deposited on the fiber core (see Fig. 3).

Note: Always perform the cleaning procedure described below for cable connectors prior to fiber optic cable installation. Whenever possible, inspect each connector before connecting it to its mating adapter. This can be done using a simple 100x illuminated microscope (fiberscope). Examples of a clean and dirty fiber end are shown below:

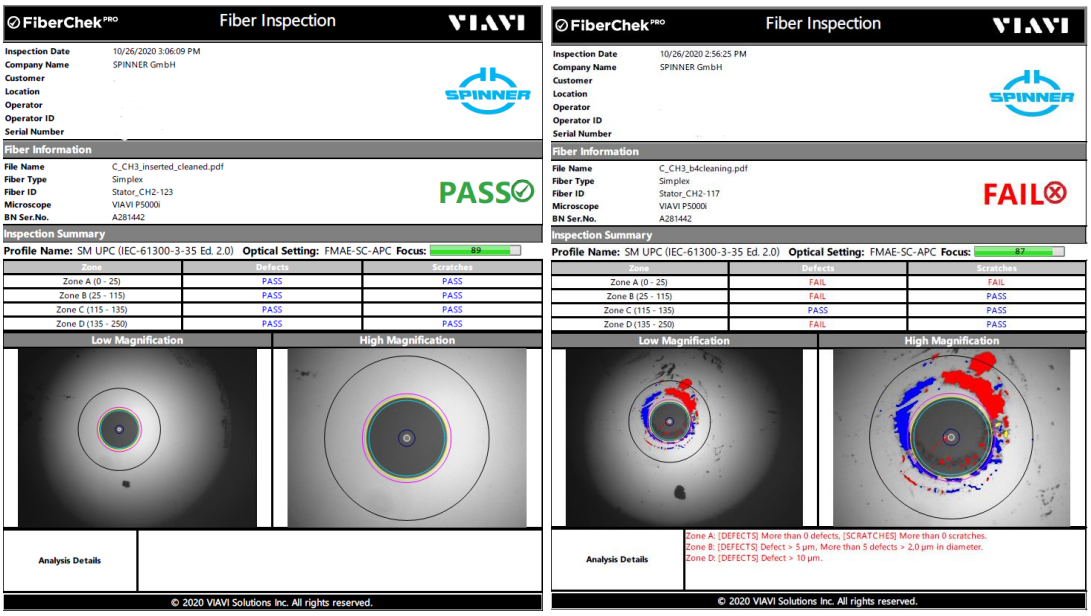

Figure 3: Clean and contaminated fiber endface

If possible, always keep a protective cap or dust cap on unplugged fiber connectors as delivered by SPINNER. Note: Unused protective caps should be kept in a clean place, like a resealable container in order to avoid contamination and transfer of dust to the fiber.

SPINNER suggests using fiber-cleaning materials only once. If optic grade wipes or tips are used to clean the fiber endface, they should be discarded immediately after the fiber surface has been wiped.

How to clean:

Compressed air:

For rough cleaning and removal of dust particles you can use compressed air. Several blasts directed at the fiber end and away from any person are usually sufficient.

Fiber Optic Cleaning Products, e.g. commercially available lint-free wipes:

Apply a small amount of a designated fiber optic cleaning fluid on a part of a lint-free wipe. As an alternative, you can use isopropyl alcohol or acetone (provide good ventilation!). Lightly press the fiber endface or connector on the moistened area of the wipe and drag it towards and onto the dry area. Dispose of the used wipe.

After cleaning inspect the endface of the connector with a fiberscope. State-of-the-art fiber microscopes automatically evaluate the endface according to specified standards and give a pass/fail result (see Fig. 3). In case of a negative result send the FORJ or cable back to SPINNER for reworking (e.g. polish) the connector.

5 Handling of Fiber Optical Rotary Joints

Most of the FORJs consist of several FO connectors on each side (i.e. stator and rotor) and the comparatively heavy body of the rotary joint. Additionally, the system is typically installed in rotatable systems, which are in particular moving versus each other, and often the FORJs have to withstand lateral movements or vibrations and shocks. At the same time, FORJs are high performance components where the single fibers are adjusted at highest precision. Forces on the body or misalignments lead to degraded performance of the FORJ.

From this starting position a couple of guidelines arise:

- Avoid dropping a FORJ on the floor or on a table.
- The FORJ bodies are cylindrical – use V-notches or other fixations of the FORJ during the assembly process to secure it from rolling off tables and the like.
- Carefully mount the FORJ without radial or axial forces (ref. to TD-00057 Installation Guidelines)
- Take care with the alignment of the rotational axis of the FORJ with regard to the rotational axis of the system.
- During installation, handle the fiber/cable as described above.
- Ensure proper and secured transition of the fiber optical cables from and to the FORJ. Follow the cleaning instructions for connectors as described above.

Typical Test Procedure:

- Clean & Inspect the connectors of the laser source and power meter
- Clean & Inspect the connectors of the patch cords
- Connect the laser source and the power meter for performing a calibration to 0 dB.
- Adjust laser source & power meter to the different wavelengths
- Connect the laser source to the patch cord on the rotor side
- Connect the power meter to the patch cord on the stator side
- Measure the insertion loss during a full rotation to find the minimum and the maximum insertion loss values determining the related insertion loss variation over rotation.
- Repeat the procedure for all necessary wavelengths and directions.

6 Torque of Fiber Optical Rotary Joints

Users of slip rings or of other rotating equipment may not be aware of the special requirements of FORJs. As the alignment of optical beams must be highly precise, proper mechanical components are required. Thus, the bearings have a low axial and radial clearance, and the gearing box is backlash free. This leads to precisely working units during *continuous* rotation.
However, operators often test FORJs in their hands where continuous rotation is not possible, but *gradual* rotation is. In this case, other effects occur:

- Stick-Slip Effect, i.e. a local cogging torque of the bearings.
- Gearbox toothing: the smallest irregularities in the gears can lead to slight jamming of individual teeth.
- Optional rotary seal: a rotary seal has a significant contribution to the torque.

These effects are due to a profound tradeoff and are a sign of the high robustness of the components.

7 Troubleshooting

Problem	Possible causes	Corrective action
Unstable optical signals / Optical signal outside of the specification	Incorrectly closed connector	Disconnect optical cable. Clean connectors and coupler. Clean fiber endface. Follow TD-00283
	Dirty fiber endface	Clean connector and bulkhead. Clean fiber endface. Follow TD-00283
	Damaged optical fiber	If available, use a fiber fault locator (e.g. FiberCheck) to determine the fault location. Return rotary joint to SPINNER
	Incorrect polish UPC vs APC	Contact SPINNER
Non available optical signals / FO link	Damaged optical fiber	Return rotary joint to SPINNER
	Wrong designation of channels	Use a fiber fault locator (e.g. FiberCheck) to determine the correct FO channel
	Patch cords have different fiber parameter (e.g Multimode / Singlemode)	Check the specification of the patch cords and FORJ or use a fiber microscope.
	Optical fiber bent below the minimal bending radius	Return rotary joint to SPINNER