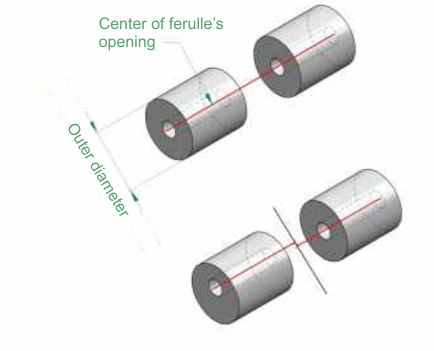
Optical connector parameters:

CONCENTRICITY OF FIBER OPTIC FERRULES

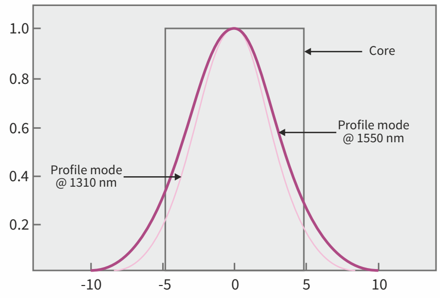
Fiber optic transmission enables transferring information for remote distances, however because of limitations resulting from various cable lengths, it was necessary to create a method of connecting the particular elements which form an optical fiber line. Fiber optic connectors are basic and indispensable elements of any fiber optic line, which provide the possibility of designing a connection which can be separated. In the place of optical fiber connection, a power loss occurs, consequently fiber optic connectors are characterized by two principal parameters: Insertion Loss and Return Loss.

The attenuation of each optical fiber line is determined by the quality of a connector. A ferrule often made of ceramic, is the central and crucial part of an each connector. Firstly, a fiber is placed in a ferrule's opening, then a ferrule is carefully polished, which ensures suitable shape and maximum smoothness of its parts. Final geometric parameters determine insertion and return loss, which are therefore based on **ferrule's concentricity** - a parameter often omitted and unappreciated.

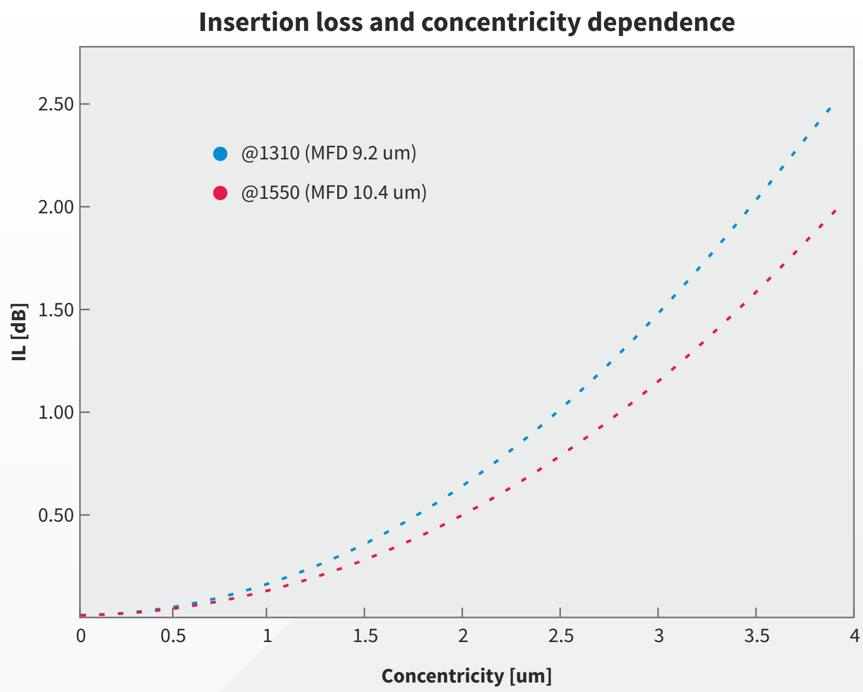
The concentricity of the ferrule is usually determined by moving the ferrule's opening axis against its center. In the case of high quality connector, the ferrule's opening, in which optical fiber is placed, is not always situated in the centric middle. For the singlemode fiber, the core diameter is 9 μm (with 125 μm sheath diameter). Very small dimensions of the fiber cores require high quality fiber optic connections elements. The quality of optical connector (primarily its IL and RL) depends on the semi-finished products in which a class as well as a quality of the ferrule play the key role. In the picture 1, various connections of two optical- fiber ferrules are presented. At the top part of a scheme, a situation in which high quality ferrules and their openings are characterized by prime centricity, which make axes to cover each other, then light goes from one connector to another without any loss. Such connectors are characterized by low and repeated insertion loss (especially in the random connections). In the other case (bottom part of picture 1) low-quality with poor concentricity ferrules were used.



When two fiber optic connectors with such non-centric ferrules are linked together, their cores do not cover each other, which therefore results in a very low insertion loss, especially in shorter waves. It is connected with the fact that, the diameter of the module field (MDF) depends on the wave-length for example for the G.652 fiber, MDF@1310 nm it amounts to approx. 9.2 μm and for MDF@ 1550nm to approx. 10.4 μm (Picture 2). It has the consequences in fewer insertion loss for long waves, since the second core "catches" more power. Insertion loss dependence on wave length is illustrated in the graph (Picture 3 on next page).



Moreover, the producer who uses low quality ferrules might not even be aware of the fact, that at the same time he launches connectors with very high attenuation. It results from the fact, that during quality control the producer is measuring the attenuation of connectors with regard to reference connector with controlled concentricity (with accordance to PN-EN 61300-3-34). Meanwhile, the user performs random connection of two connectors with the unknown concentricity. During the measurement as regards reference connector, the offset between ferrules' axes is significantly smaller (due to excellent concentricity of the ferrules' reference connector). Thus, measured connector's with the reference connector, will be characterized by fairly little insertion loss, than random connection obtained in the area. As an example illustrated in picture 3, **the connector with 1 um ferrule can have approx. 0.2dB attenuation which is measured with regard to reference connector but almost 2dB in random connection**. Would you like to use such connector in your network? Would you like to have a connector, which reaches 1.5 dB higher attenuation when connected to next adapter? Does the purchase of such patchcords look apparently like 'fake' saving? If you possess a connector in the network which has higher attenuation for 1310 nm wave, than for 1550nm wave, there is a high possibility that you have bought a poor quality patchcord with non-centric ferrule.



The values of connectors' attenuation in a random connection are one of the main attribute of high class producers in comparison to producers who offer dubious and poor quality connectors. The cost of ferrule is the main component in the total cost of fiber optic connector, consequently there is a temptation of using one of the cheapest materials but **initial savings will have definitely later consequences in the final quality of the product**. Not to mention the fact that fiber optic connector class is determined by a quality and tolerance parameters of a ferrules. The PN-EN- 61755-3-1 & PN-EN 61755-3-2 norms define maximally acceptable non-centricity of the fiber optic connector for the particular attenuation IL class as a table 1 illustrates.

	Class A	Class B	Class C	Class D
IL (average values for random connections)	——	<= 0.12 dB	<= 0.25 dB	<= 0.25 dB
IL (random connections max ≥97%)	——	0.25 dB	0.50 dB	1.0 dB
Concentricity of APC connectors	——	<= 1.0 µm	<= 1.4 µm	<= 1.5 µm
Concentricity of PC connectors	——	<= 1.2 µm	<= 1.5 µm	<= 1.6 µm

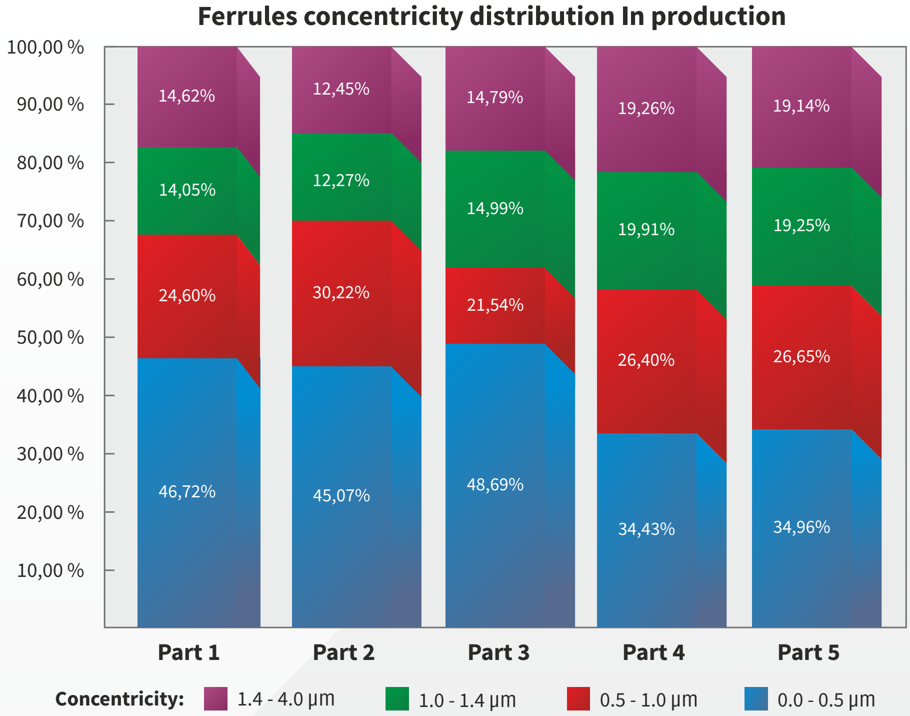
Tabela 1.

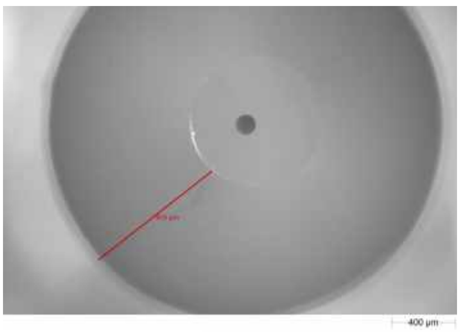
The A class has not been normalized yet , but mostly the non-centricity limit for this class of the pins is adapted as ≤ 0.5 µm. There is no possibility of producing a connector of the A, B or even C class, using exclusively low quality ferrules and without a core placement, even if the producer of connectors have different view.

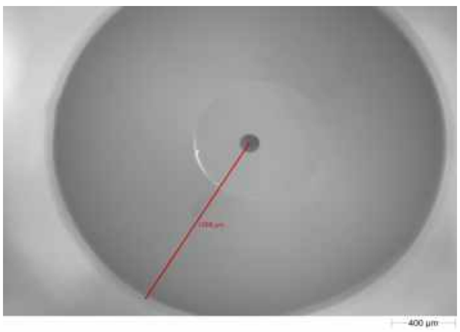
We need to bear in mind that tolerance concerning manufacturing stage cause that **suppliers of ferrules always have some rest in this process** - those are ferrules which do not meet the technical and necessary requirements, often centricity parameter. The bar chart demonstrated in picture 4, illustrates typical distribution of ferrules' concentricity from a few production batches of our supplier. **Ferrules of a low concentricity >1.6 can be bought seven times cheaper than high class ferrules.** Is it the secret of their low price?

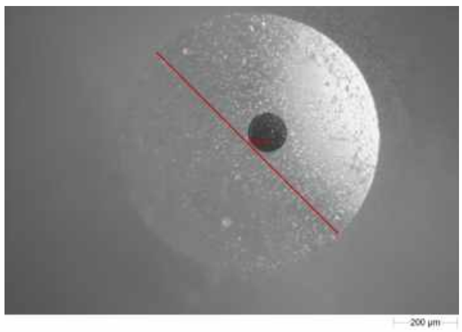
Poor quality materials always signify that the final product will be of low quality, whereas in an fiber optic market segment, only prime quality products with tolerances below 1um are required. **Fiber optic connectors produced by Fibrain company always use only high class components**. Therefore, Fibrain make use Ferrules zirconium ceramics ferrules, which have comparable temperature factor as an optical fiber. As a result, it is a guarantee of optically stable connector in a wide range of temperatures. Our ferrules are characterized by high precision including concentricity which is verified by additional measurements in order to ensure repeatability of the connection and low losses in random connections. Furthermore, it indicates additional costs, which has the results in the price of final product. Nevertheless, majority of people have already grown up from the faith in the Santa Claus and they know perfectly that there is nothing for free in life.

Aren't peaceful night's sleep and stable network more important for a subscriber than just apparent and 'fake' savings?









Fibrain Sp. z o.o.

Wspólna 4A
35-205 Rzeszów, Poland

tel. +48 17 866 08 12
tel. +48 17 866 08 13
fax: +48 17 866 08 11

www.fibrain.com
info@fibrain.com