

## White paper

# Butt-Joint vs. Expanded Beam

### Abstract

In fiber optics there are two ways of connecting two fibers, a physical connection called butt-joint and a non physical connection often utilizing expanded beam technology.

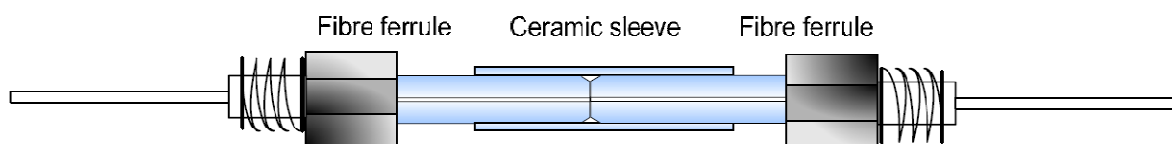
Both the connector types have their advantages and areas of use and in this paper we will explain the differences and how to choose the correct connector type.

### Introduction

The use of fiber optics has increased significantly over the last 10 years. Fiber optic cables have many advantages compared to copper wires but the conventional method of connecting fibers also have major disadvantages, they are sensitive to dust, oil and other environmental factors. As an alternative to the normal physical contact connectors expanded beam fiber optics has been developed which drastically reduces the effects of harsh environments. This enables fiber optics to be used in areas previously considered too rough for fiber such as heavy industry, avionics, railway, outdoor broadcasting and geophysics.

### Butt-Joint connectors

In Butt-Joint connection two polished fiber ferrules are connected inside a ceramic sleeve as the figure below shows.



The butt-joint connector has a low insertion loss, usually around 0,2 dB and gives a stable signal as long as the environment is controlled. The two fiber ferrule stay pressed together by springs and are easily attached and removed. The core of the fiber is normally 9-10  $\mu\text{m}$  in case of single mode and 50 or 62,5  $\mu\text{m}$  in multimode.

A misalignment due to vibration or rapid change of temperature or dust particles in the light pathway can easily disrupt the signal totally.

The cost of using butt-joint connectors is low and that is one of the reasons that it is the by far most usual way of connecting two fibers.

## Expanded beam connector

In the expanded beam technology the light beam coming out from a fiber is expanded and collimated by a spherical lens and the light is transported through air to a second lens where it is focused down into a second fiber. This is described in the figure below.



The single mode expanded beam is about 2.400 times enlarged compared to when it exits the fiber core. This makes it considerably less sensitive to dust, vibration and temperature changes. It has a slightly higher insertion loss than the butt-joint connector, around 1,0-1,5 dB for single mode and 0,5-1,0 dB for multimode.

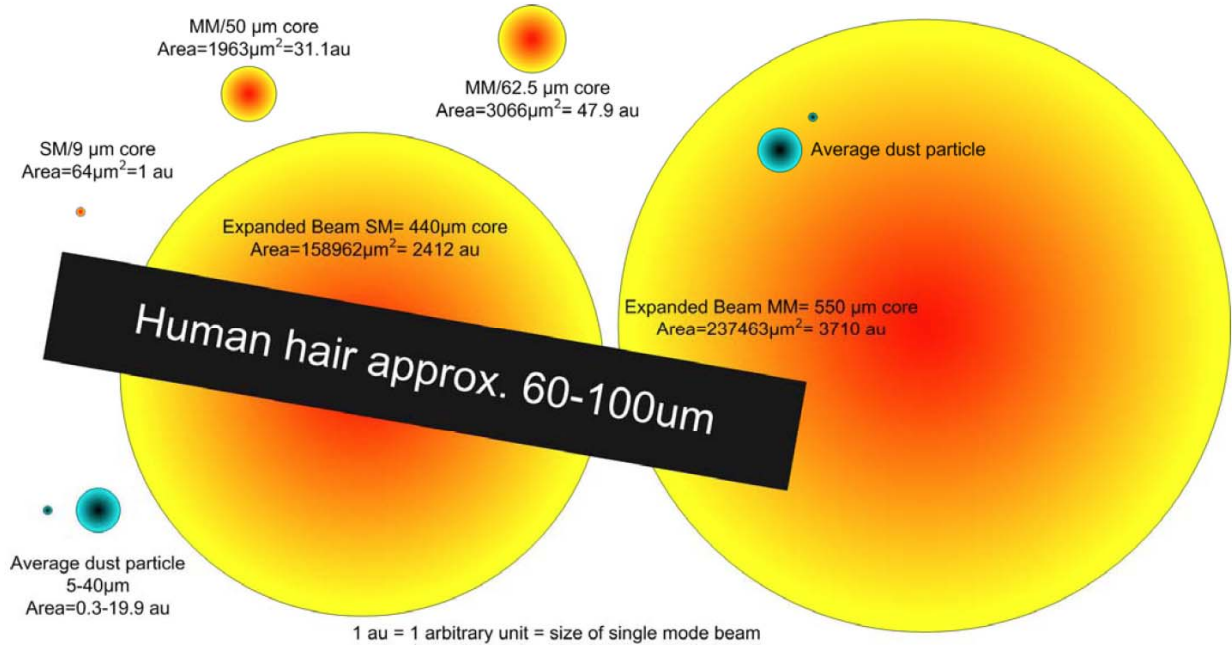
Due to the fact that the expanded beam technology uses free air communication the efficiency stays the same for a very long time, it does not deteriorate the same way a butt-joint connector does.

## Expanded beam vs. Butt-Joint

The fact that the butt-joint connector uses a small beam makes it vulnerable to dust and vibrations and can therefore only be used in a controlled environment . The process of manufacturing butt-joint connector is however cheap with many standard products on the market that can be bought of the shelf. Where the environment can be controlled for temperature, vibration and dust ingress combined with the ability to maintain the connector with regular cleaning then a Butt-Joint would be a reasonable choice.

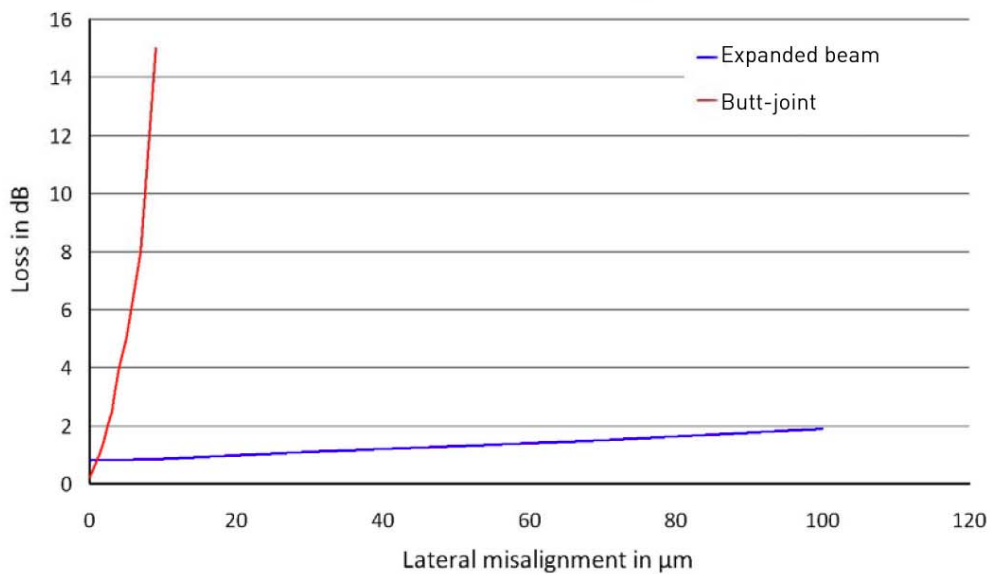
In recent years the need for high band width solutions in industries such as transport, avionics, milling, heavy industries and so on have exploded. Copper solutions do not have the capability of transporting this volume of information at the speeds required. Expanded beam connection is gradually being utilized in these areas and has proven very efficient.

The figure below shows the butt-joint and expanded beam size.



The size also makes the expanded beam relatively insensitive against lateral misalignment between connector parts, see table below, and this make it less sensitive against vibration and rapid temperature changes.

### Loss due to lateral misalignment



While Expanded Beam Connectors are insensitive to lateral misalignment they are more sensitive to angular alignment. Single mode connectors have to be aligned within 0,06 degrees to get a loss of less than 0,5 dB. This problem has been solved differently by companies that manufacture expanded beam connectors.

Due to the fact that the expanded beam has increased in use, a world standard has recently been developed to ensure that expanded beam products of different companies still will be compatible.

## Conclusion

The butt-joint and expanded beam connectors are not to be seen as competitive connector types but as complementary types of connectors used for different types of environment and applications. The butt-joint connector is cheap and effective in a controlled environment but does not work in rough environments. The expanded beam is more costly and is therefore not an option in low-cost applications but is ideal for reliable large scale information transfer in rough environment such as military, transport and heavy industry applications. The expansion of the beam makes the expanded beam connectors less sensitive against dust, vibrations and rapid temperature changes but it also results in a tight tolerance in the angular misalignment of the connector parts.