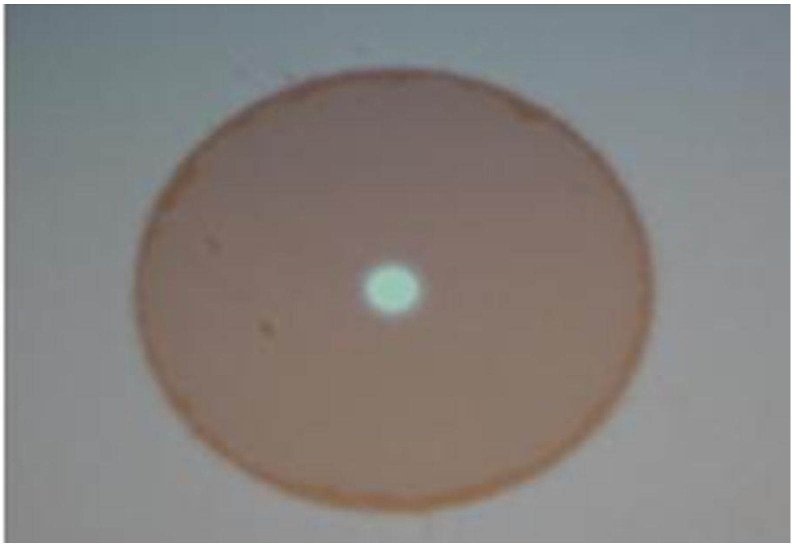
Interferometer Testing

To date, when one inspects the end face of an optical fiber connector in the field it is normally accomplished using some type of magnifying device, normally a 50 power to a 400 power microscope. In reality what we see is a two dimensional view of a three dimensional object as shown in figure 1. The end face should be clear and clean.

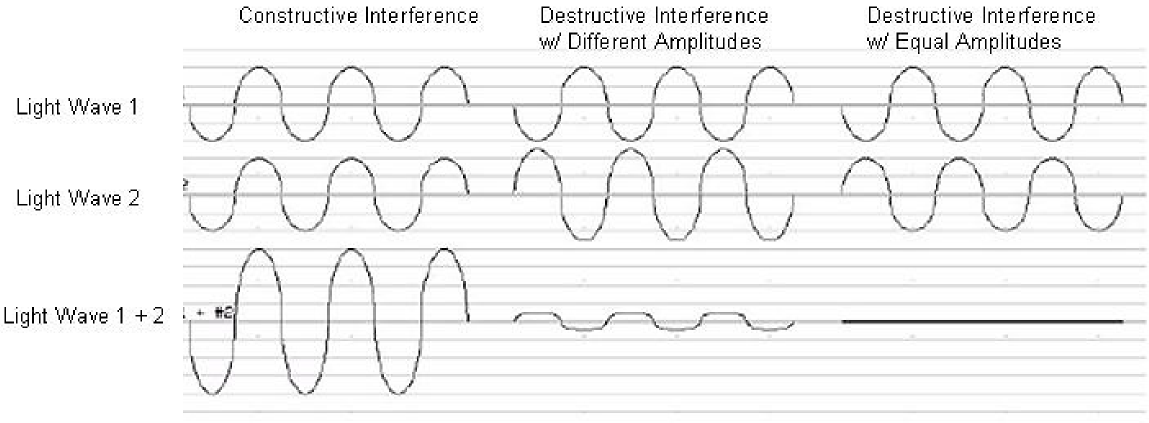
Figure 1 Optical Fiber Connector End Face (200X)



The connector end face shown in figure 1 meets these criteria. In order to view the end face in three dimensions requires the use of an additional test set called an interferometer. The interferometer works using the principal of light wave interference.

Light wave interference occurs when two or more waves of the same frequency or wavelength combine to form a single wave whose amplitude is the sum of the amplitudes of the combined waves. Constructive and Destructive interference is the most striking examples of light wave interference. Constructive interference occurs when the light waves are completely in phase with each other (the peak of one wave coincides with the peak of the other wave). Destructive interference occurs when the light waves are completely out of phase with each other (the peak of one wave coincides with the trough of the other wave). Refer to figure below for an illustration of Constructive and Destructive interference.

Figure 2 Constructive and Destructive Interference



Interferometers can produce images and data to sub micron accuracy using the principle of wave interference. Interferometers use a single coherent light source. In order to produce two separate light waves for interference to occur, a partially reflective beam splitter is used. As the light hits the beam splitter, one wave front is transmitted through the beam splitter, though an objective lens, and to the object being examined. The other light wave reflects off of the beam splitter onto a stationary reference mirror. After both light waves are reflected off of the surfaces (the surface of the object being examined and the reference mirror), the waves combine to produce constructive and destructive interference waves, also known as light and dark fringes respectively. Each dark fringe identifies a specific height on the surface of the object being examined. Typically, two adjacent dark fringes have a height difference of 1/2 a wavelength of the light being used and can thus show a surface contour of the connector end face, very similar to the concept of contour maps which are used to show the different elevations of a land surface.

Figure 3 Surface Contours

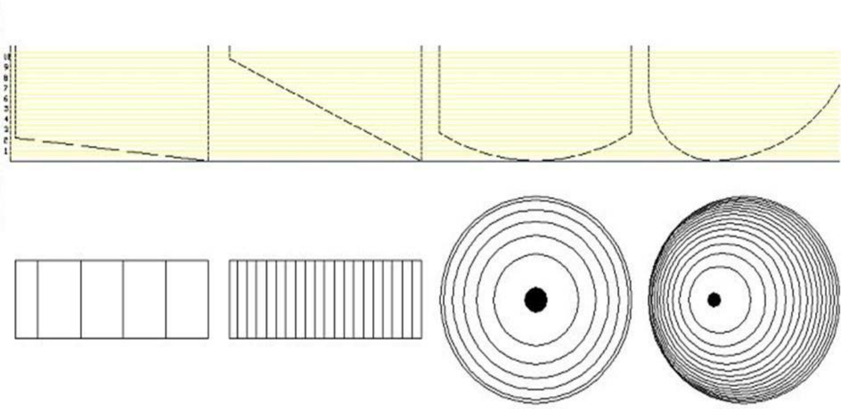
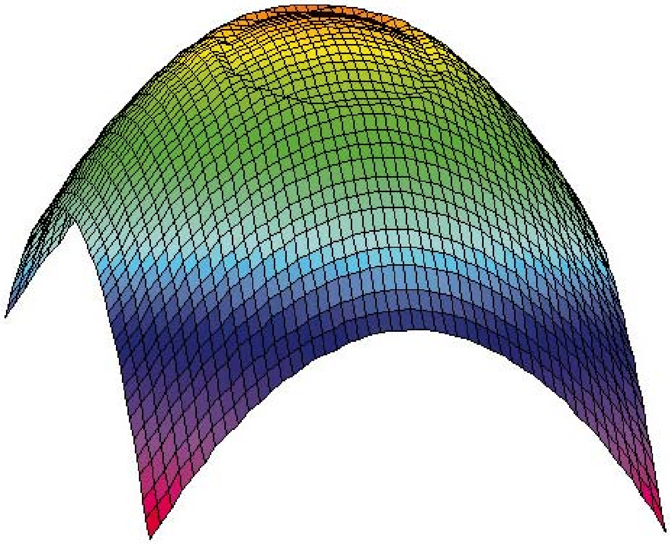


Figure 4 Three Dimensional View of Connector End Face

Based on the above, the interferometer provides 3D information about the end face geometry of the fiber optic connector.



The interferometer tests three specific components of the connector. They are the radius of curvature, offset of polish, and the fiber height.

Figure 5 Radius of Curvature

This portion of the test determines the overall diameter of the best fit sphere and its relationship to the actual end of the connector under test.

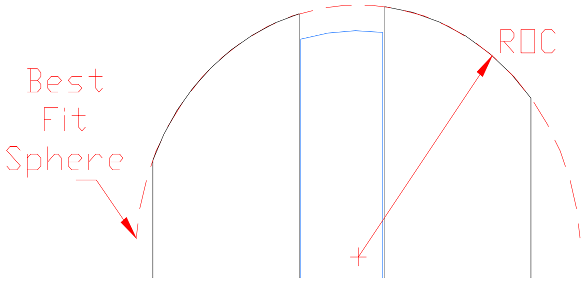


Figure 6 Radius of Curvature

Therefore, the spacing and diameter of the circular fringe pattern are directly related to the radius of curvature.

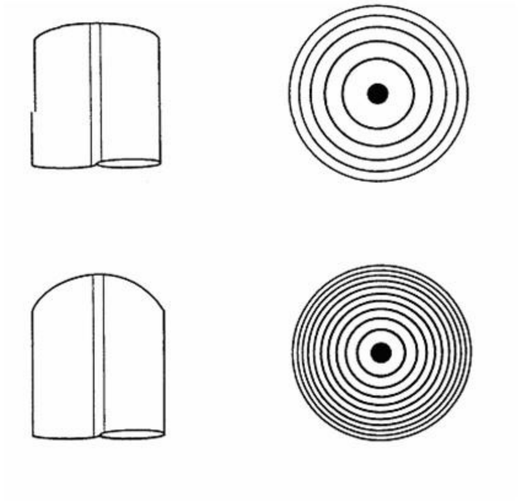


Figure 7 Offset of Polish

The offset of polish determines the actual centerline of the fiber and its relationship to the actual centerline of the best fit curve.
With the ideal connector, both centerlines would be the same.

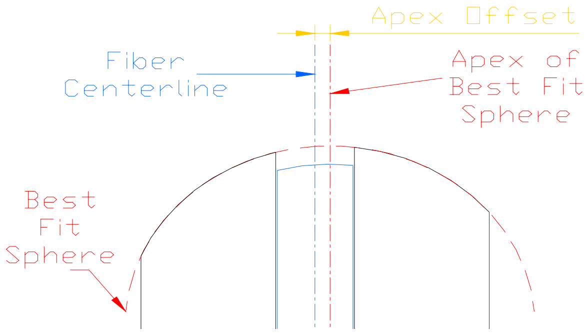


Figure 8 Fiber Height

The fiber height portion of the evaluation determines the amount of fiber that is above or below the end of the connector end face.

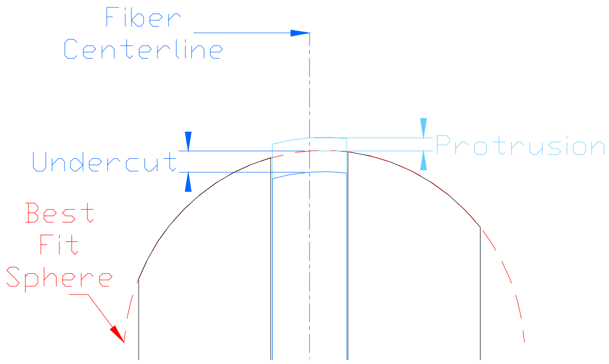
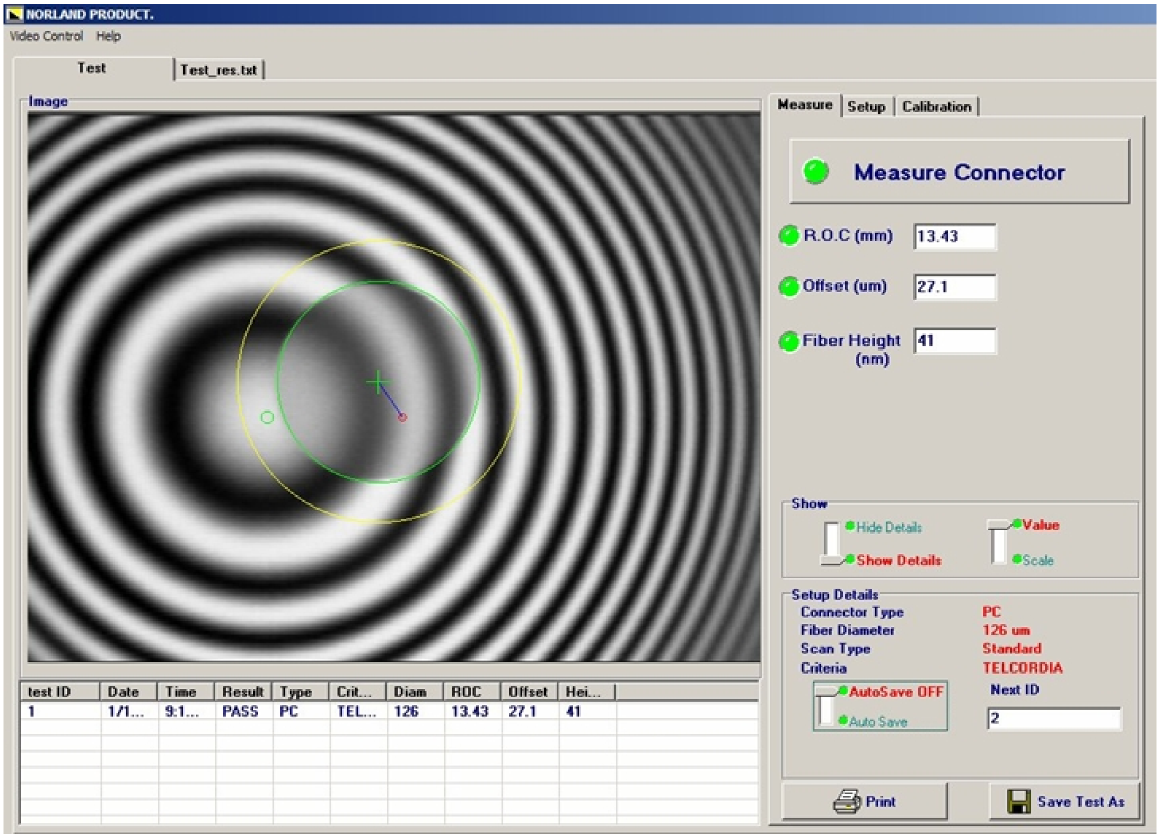


Figure 9 Test Result

Based on these three parameters, a test report may be generated.



R.O.C (mm) 13.43

Offset (um) 27.1

Fiber Height (nm) 41

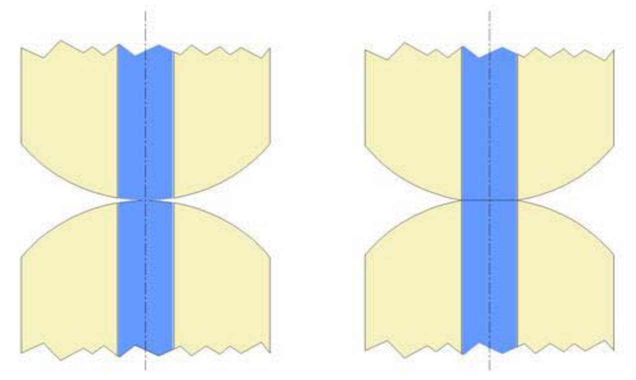
Setup Details
Connector Type PC
Fiber Diameter 126 um
Scan Type Standard
Criteria TELCORDIA

Next ID 2

test ID	Date	Time	Result	Type	Crit...	Diam	ROC	Offset	Hei...
1	1/1...	9:1...	PASS	PC	TEL...	126	13.43	27.1	41

In this case, the connector is within limits for all of the tested parameters. However, the basic question remains – why field test the connectors? To answer this question we need to examine the condition which may occur when we join two connectors and what is the relationship between the two. The objective is minimum loss as well as minimum reflectance. Optical fiber connertorization is based on the principal of Physical Contact (PC). When two “ideal” connectors are joined, the interface should be as shown in figure 10.

Figure 10 Connector Interface

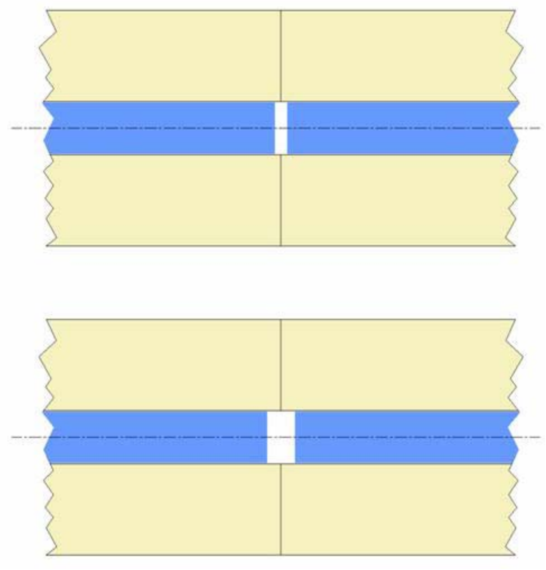


When using the PC concept the only concern is the center of the connector. The fibers are polished so that they are at the highest point and first to meet. There is no air gap. The fibers compress until the ferrules contact. However, the ferrules take the majority of the compressive force.

The use of interferometry helps guarantee optical performance by providing consistent quality control of the polishing process. This quality control assures long term stability when connectors are exposed, over time, to changes in temperature, pressure, and the affects of vibration.

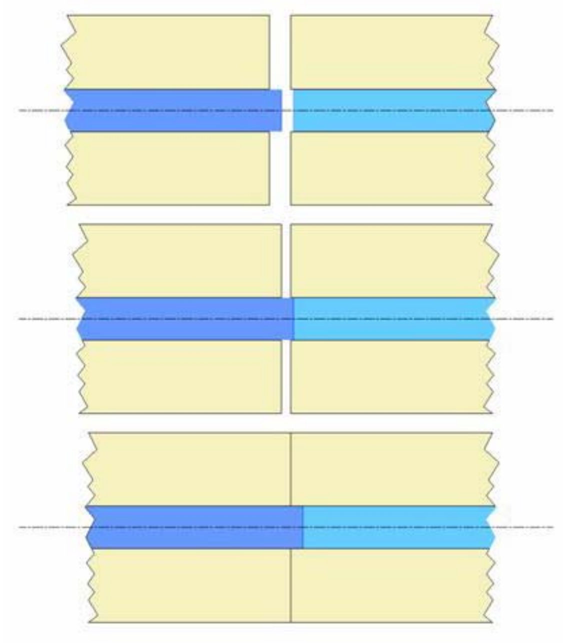
If figure 10 represents a good connector, what is a “bad” connector? Bad connectors may be one of three types. Undercut is the result of over polishing, offset as shown in figure 3, and protruding, the result of under polishing. The result of over polishing is shown is figure 11.

Figure 11 Undercut



This results in an air gap between the connectors and a corresponding increase in both attenuation and reflectance. In this instance the glass within the connector may “piston” over time. This is probably the failure most often seen. (The tech needs to get the last little scratch off of the end face of the connector) The second condition, offset may be caused by not holding the polishing puck tight and square to the lapping film during the polishing process. With the use of today’s pre-radiused connectors off set should not be a major problem. The last type of failure is protrusion. In this instance the fiber is protruding from the end of the connector as shown in figure 12.

Figure 12 Protrusion



When the end face of one connector meets with the second, something has to give. As shown in figure 12, the result is what is termed push back. The fiber on the protruding connector pushes the fiber on the second connector back into the ferrule of the second connector. This is the best case. (Have you ever wondered why a connector that was good yesterday was found to be shattered today?) Yes, under pressure, glass will break and usually at the most inopportune time.

Now, back to the original question – why should I field test my connectors with an interferometer?? From the view point of an installer, with the advent of 20 plus year warranty periods, it drastically decreases the probability of call back by the client because of bad connectors. From an end user viewpoint, what is the cost of downtime because of a failed circuit? In either case, the up front cost of interferometer testing will be greatly off set by future system performance.

Acknowledgements:
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